JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

Vol. 29 June 1936 No. 3

ENTOMOLOGISTS AND ENTOMOLOGICAL PUBLICATIONS

DURING the infancy of entomology in this country the few entomologists, all amateurs, frequently bemoaned the absence of entomological books and the difficulty of obtaining foreign works on the subject.

Nowadays there are apparently more entomological books and journals than entomologists in general care to support adequately. Aside from two journals that are the official publications of two national societies, it is my guess that most of the remaining ones live a more or less precarious existence from year to year and that deficits are not infrequently made up by generous members.

The number of persons in this country at present calling themselves entomologists must be fairly respectable in point of numbers, yet this large body is disinclined generally to spend its money for entomological publications. I do not refer to popular or semipopular works which are supported largely by tree wardens, boy scouts, superintendents of estates and part of the general public, nor to books used as class texts, but to entomological books and journals written for entomologists themselves.

The economic entomologist reads only economic literature; the systematist oftentimes is familiar only with the literature of his own specialty; the quarantine entomologist reads only mimeographed news letters and notices of quarantines; the lepidopterist never even glances at a paper on coleoptera, and this attitude is reciprocated by the coleopterist; and the bio-chemist, a recent evolutionary product, if he has any burning interest in insects, I have never heard of it.

Such a diversity of interests and a lack of sympathy for entomological activities outside of their own are no doubt partly responsible for the failure of entomologists to support fully their publications. As a rule they plead lack of funds. But I think that this is only a poor excuse, because most of them seem to find funds for cars, gasoline, electric refrigerators, liquor, vacuum cleaners, oil burners and sundry appliances designed to add to their material comfort. Were it not for purchases by libraries, grants by foundations, subsidies by individuals and the use of some of the money collected by taxation, the volume of entomological literature would be considerably reduced.

I see no practical solution for this state of affairs. If entomologists in general are happy in limiting their curiosity and their support of entomology in general, I for one would not want to disturb their happiness.

But, if they believe in their science—and most of them do—their support should be practical as well as moral.

Entomologists do not differ in many respects from the population of which they are a part. Their virtues and vanities and jealousies and love affairs are similar to those of people in general. And so are their book-buying habits.

For many entomologists, perhaps, the science is no longer a hobby, to be ridden fast and furiously. Perhaps it is a sort of respectable, income-producing trade, no longer requiring all their labor and all their intelligence. Perhaps at the end of the day they are through with entomology, and other forms of relaxation engage their interest and support. If this is their pleasure we must not dream of depriving them of it, but if the Secretary of the American Association of Economic Entomologists could make arrangements with publishing houses so that members would receive a substantial discount on the purchase of entomological books (an arrangement already in effect between certain associations and publishers), I wonder if this would help to stimulate the purchase of books by entomologists.

HARRY B. WEISS

Review

The Pioneer Century of American Entomology, by Harry B. Weiss. 1936. 320 pp. Published by the author, New Brunswick, N. J. $4.25 postpaid.

The appearance, within six years, of three large volumes on the history of entomology, where none existed before, might lead one to expect that a considerable amount of useless duplication could not have been avoided. This newest volume, however, does not in any way duplicate the excellent "A History of Applied Entomology" by L. O. Howard, or Essig's "A History of Entomology."

"The Pioneer Century of American Entomology" is a biographical account, chronologically arranged, of some three or four hundred persons who wrote about insects in America previous to 1865. No attempt is made to trace and follow major lines of development in the science; the author has chosen a strictly chronological arrangement of his material and one individual succeeds another in a somewhat monotonous procession of mostly unconnected items. The work displays a remarkable understanding of the historical background, social setting, and interrelations of the various factors which entered into the life of struggling naturalists in pioneer days. It would seem that it could only have been written by one thoroughly steeped in the lore of early Colonial history, as well as versed in entomology. Entomology will ever be indebted to Dr. Weiss for the inconceivable patience and labor involved in gleaning these items of interest from the thousands of obscure and dusty pages in which they originally appeared. Most readers will be surprised at the preponderant part played by ministers and physicians in early biological work and at the tremendous and sustained interest in silk culture in America during this period. It is apparent that a number of insects such as horse flies, "muskitoes," "tykes," joint worms, wheat midge, and others, were relatively more important and troublesome then than now.

It would be interesting, if a census could be taken, to know how many of the student and official entomologists in this country could tell or name: the first publication in America devoted exclusively to insects, the first insect to be described from North America, when the first really scientific observations upon American insects were made, the first American entomologist to propose a system of orders of his own, when the first annual scientific bibliography was published in the United States, who made the first record of the periodi-

cal cicada and of its 13-year variety, the first attempt to introduce the Italian honeybee to America, "the greatest entomologist this country has ever produced," "the most worthless American insect book," or how entomologists killed their insect specimens before the cyanide bottle came into use. Or, looking beyond the American shores, who used the binomial system of nomenclature before Linnaeus, who first used families as subdivisions of orders, who first brought the conception of species into natural history, how many of Linnaeus' 2400 described species occur in the United States, or who first discovered parthenogenesis in aphids and in silkworms. The answers to these and hundreds of other interesting questions may be found in this unique volume.

The work not only gives the name, birthplace, principal activities, adventures and accomplishments of everyone who wrote about insects, from Fernandez de Oviedo's mention of the numerous and cruel insects of this region in 1526, down to the time of Walsh, Trimble, Cresson, Shimer, Grote, Packard, Lintner and Fitch; it is also a bibliography of all the known writings in any way relating to entomology during that entire period. The chapter headings are: Entomology in the Accounts of Early Travelers (1588–1723), The Entomology of Early Books and Papers (1731–1800), Thomas Say and His Contemporaries (1817–1831), From Zimmerman to LeConte (1832–1845), Asa Fitch and Other Entomologists (1845–1854), The Glover and Osten-Sacken Period (1855–1860), From Walsh to Cowan (1860–1865), The Entomology in Agricultural Periodicals Before 1865, Scientific Societies, Scientific Journals, and Exploring Expeditions Contributing to the Progress of American Entomology, Some Notes on Canada, and Entomology in Europe During the Pioneer Century in America. A bibliography of 25 titles and a fairly adequate index complete the volume.

The work is naturally not above criticisms. There is almost as much of human interest in the pages, as of entomology, including, however, a good deal of matter that seems to the reviewer irrelevant and unnecessarily detailed. It is a ponderous volume, actually weighing over four pounds. While the mimeographing is creditably free from typographical errors, such offset printing can never have the artistic appeal of the printed page. If the matter had been condensed to that of actual entomological interest, the author might have been more successful in finding a publisher who would have brought it out with the illustrations, which, he states, unfortunately had to be omitted in the mimeographed edition. One might wish that the major content of the various chapters and paragraphs were indicated by some system of headings or tables of contents. The monotony of pages, unbroken by headings or illustrations, leaves nothing but one's thirst for information to invite perusal. There is a good deal of material that is not at all, or very remotely, entomological and which scarcely seems complete enough from other points of view to warrant its inclusion. As an example, the devotion of two or three pages to a "Natural History of Barbados," including a list of names of subscribers to the book—a work avowedly of little or no significance—seems unnecessarily extended. Nevertheless, the reviewer predicts that hundreds will be impelled, as he has been, to read the book greedily from cover to cover, because it is a tremendous storehouse of interesting facts not otherwise accessible. It should be one of the chosen list of works recommended to graduate students for reading.

C. L. METCALF. 5-23-36

Horticultural Inspection Notes

SEED-CERTIFYING AUTHORITIES, plant pathologists, can-crop specialists and other interested parties representing some of the principal tomato-canning states attended an informal conference held at Tifton, Ga., May 11 and 12 to consider plans for disinfection and certification of tomato seed.

J. H. GIRARDEAU was appointed State Entomologist of Georgia to succeed M. S. Yeomans, according to recent reports from that office.

ACCORDING TO A. C. FLEURY, Chief of the California Bureau of Plant Quarantine, the rhododendron white fly, *Dialeurodis chittendeni*, was recently found on two shipments of native Tennessee rhododendron plants consigned to California. A report on this interception and specimens of the insect in question were submitted to the Bureau of Entomology and Plant Quarantine, following which a preliminary survey in Tennessee was made which partially established the infested area. A further survey is being planned by the Tennessee officials.

ACCORDING TO G. M. BENTLEY, State Entomologist of Tennessee, there are more nurseries in that state than any other of the southern states. The state maintains a State Nurserymen's Association consisting of some 200 members. Once a year they hold an annual convention and during the summer frequently have a meeting at one of the larger nursery centers. The last convention was held at Knoxville on January 21, 22 and 23, 1936, with a splendid attendance. Fifteen new members were added to the association at this convention. Officers are: R. H. Jones, Nashville, president; David Cartwright, Collierville, vice president; G. M. Bentley, Knoxville, secretary-treasurer.

UNDER A RECENT RULING of the Arkansas Plant Board, seed sweet potatoes and sweet potato plants shipped into Arkansas must bear a permit issued by that Board. Arkansas-grown sweet potatoes must be marked on the container to show the name, address and application number, as well as each bundle of plants within the container. These regulations are directed against the sweet potato weevil and other pests of this crop.

A QUARANTINE on the shipments of raspberry plants has been promulgated by the New Jersey State Board of Agriculture, requiring a special certificate issued by the proper state official of the state of origin, attesting that the plants contained in the shipment have been field inspected twice by an official state inspector and found to be practically free of virus disease.

WHITE PINE BLISTER RUST control areas are established in Wisconsin by General Order No. 3E effective January 1, 1937, promulgated as a result of a recent hearing held by the Commissioners of the Department of Agriculture and Markets. The European black currant, *Ribes nigrum* L., and all of its horticultural varieties were also designated as hosts or carriers of a dangerous plant disease within the meaning of the Wisconsin statute and their eradication directed without compensation to the owners. The regulations provide that white pine stands, as a condition of being protected, must be conspicuously posted to the effect that the *Ribes* have been eradicated and that the planting of *Ribes* within 900 feet is illegal. Official warning tags furnished by the state entomologist must be attached to all *Ribes* moved intrastate and a federal control-area permit (Form 415) is required on all interstate shipments.

THE TWELFTH ANNUAL MEETING of the Central Plant Board was held at Ames, Iowa, on March 4. Messrs. Hoyt, Annand and Hambleton of the Bureau of Entomology and Plant Quarantine attended and discussed problems pertaining to regulatory work. Ten of the thirteen central states belonging to this group were represented, including Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Nebraska, Ohio and Wisconsin. Professor A. G. Ruggles was elected president, P. T. Ulman secretary, and Dr. Carl Drake as representative on the National Plant Board to succeed Professor Geo. A. Dean. The meeting place selected for next year was Kansas City, Mo. This meeting was held in conjunction with the North Central States Entomologists, the National Codling Moth Conference and the National Plant Board. More than 250 entomologists attended these various sessions held at Ames. Six of the eight members of the National Plant Board were present, including W. C. O'Kane and J. F. Adams of the Eastern Plant Board, R. W. Leiby and M. S. Yeomans of the Southern Plant Board, and Geo. A. Dean and E. L. Chambers of the Central Plant Board. J. F. Adams was elected chairman, M. S. Yeomans, vice-chairman and R. W. Leiby re-elected secretary for the ensuing year.

THE STATE LEADERS of the various states in which barberry eradication work is being carried on held their annual winter conference at Chicago on March 12 to 14 inclusive. Dr. S. B. Fracker, Chief of the Division of Plant Disease Control, in charge of this work carried on in cooperation with the various states, and his assistant William L. Popham represented the Bureau of Entomology and Plant Quarantine from the Washington office. Raymond O. Bulger, in charge of field operations, acted as chairman. The state leaders in attendance included R. W. Bills, Illinois; W. E. Leer, Indiana, D. R. Shepherd, Iowa; L. A. Ames, Massachusetts; G. N. Frandsen, Missouri; M. E. Yount, Nebraska; H. Atwood, Ohio; L. K. Wright, Pennsylvania; G. W. Eade, South Dakota; G. E. Matheny, Virginia; T. Van Zanden, West Virginia; V. O. Taylor, Wisconsin; Ivar Twilde, Montana; Geo. C. Mayoue, North Dakota; E. A. Lungren, Colorado. D. G. Fletcher of St. Paul, secretary of the Conference for the Prevention of Grain Rust, and Dr. E. C. Stakman of the University of Minnesota took active parts in the discussion.

JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

Vol. 29 AUGUST 1936 No. 4

Contents

PAPER-READING SESSION, FORTY-EIGHTH ANNUAL MEETING, ST. LOUIS, MO.

Brood Study of the Codling Moth for One Decade, *Thomas J. Headlee* 639
What is Happening to the Codling Moth? *Leonard Haseman* 646
Large-scale Test of Orchard Sanitation to Control Codling Moth, Progress Report, *L. F. Steiner* and *A. J. Ackerman* 648
Eight Seasons' Tests in Codling Moth Control in Michigan, *Franklin Sherman III* 653
Substitutes for Lead Arsenate in Codling Moth Sprays, *C. G. Vinson* 655
Three-year Study of Calcium Arsenate for Codling Moth Control, *J. Marshall* and *Kermit Groves* 658
New Method of Codling Moth Control in Theory and Practice, *G. E. Marshall* .. 669
The Periodical Cicada, *J. A. Hyslop* 671
Occurrence and Sequence of Mosquitoes in Southeastern Arkansas in 1935, *W. R. Horsfall* 676
Food Plants of Some Arizona Grasshoppers, *E. D. Ball* 679
Study of Chinch Bug Populations in Ohio, *F. B. Whittington* and *L. L. Huber* ... 684
Relative Resistance of Selected Strains of Corn to European Corn Borer, *G. A. Ficht* 687
Three Factors Affecting Laboratory Rearing of European Corn Borer Larvae, *Ralph Mathes* 691
Larger Apple Curculio in Wisconsin, *P. O. Ritcher* 697
Pupal Period of the Hessian Fly, *H. H. Walkden* 701
Hordeum Grasses as Hosts of the Hessian Fly, *E. T. Jones* 704
Influence of Certain Factors on Oviposition Responses of the Cherry Case-bearer, *John H. Lilly* 710
Studies of Certain New Wetting Agents and Their Application with Insecticides and Fungicides, *Ralph E. Heal*, *John B. Schmitt* and *Joseph M. Ginsburg* 714
Miscible Oil Emulsifiers and Spreaders, *C. O. Eddy* 722
A New Form of Cryolite, *S. Marcovitch* and *W. W. Stanley* 725
Relation of Soil Utilization to Wireworm Injury, *John H. Hawkins* 728
Studies on Cucumber Beetle Control in 1935, *George E. Gould* 731
Rôle of Light Traps in Control of Mushroom Springtail, *C. C. Compton* 735
Laboratory Studies on Toxicity of Nicotine and Soap to Gladiolus Thrips and Onion Thrips, *Taeniothrips simplex* (Morison), *Thrips tabaci* Lindeman, *H. D. Tate* and *Floyd Andre* 738
Toxicity of Kerosene Steepates of Derris and Pyrethrum to Some Potato Insects, *T. C. Allen* 742
Heat Treatments for Control of Bulb Mite on Tuberose, *C. A. Weigel* and *R. H. Nelson* 744
Survey of Insect Fauna of Some Michigan Trout Streams in Connection with Improved and Unimproved Streams, *W. F. Morofsky* 749
Liquid Applications to Control Peach Borer and Lesser Peach Borer, *S. C. Chandler* 754
Tests on Baits for Oriental Fruit Moth, 1935, *S. W. Frost* 757

SECTION OF EXTENSION ENTOMOLOGY, PAPER-READING SESSION, FORTY-EIGHTH ANNUAL MEETING, ST. LOUIS, MO.

Fighting Chinch Bugs in Iowa, *A. D. Worthington* and *G. C. Decker* 760
Obtaining Cooperation of Growers in Studying Spray Schedules, *George D. Jones* 764

SECTION OF PLANT QUARANTINE AND INSPECTION, PAPER-READING SESSION, FORTY-EIGHTH ANNUAL MEETING, ST. LOUIS, MO.

Recent Developments in Canadian Regulatory Work, *L. S. McLaine* 766
Cooperation of Officials of the Kansas Port of Entry in Assisting the Kansas Entomological Commission to Enforce Regulatory Measures, *George A. Dean* 772
Recent Work in Control of Gypsy Moth and Brown-tail Moth, *A. F. Burgess* ... 773
Japanese Beetle in the Middle West, *J. Carl Dawson* 778
The Chinch Bug Situation in Iowa, *C. J. Drake* and *G. C. Decker* 781
Progress in Dutch Elm Disease Eradication, *L. H. Worthley* 785

EASTERN BRANCH, PAPER-READING SESSION, SEVENTH ANNUAL MEETING, BALTIMORE, MD.

Toxicity of Rotenone and Pyrethrins, Alone and in Combination, *Richard H. LePelley* and *W. N. Sullivan* 791

Third Generation and Method of Migration of Chinch Bug in Southwestern Oklahoma, *Ralph O. Snelling* 797

SCIENTIFIC NOTES 804

EDITORIAL 808

REVIEW 809

CURRENT NOTES 809

HORTICULTURAL INSPECTION NOTES 743, 756, 765, 771, 780, 790, 811

NOTICE TO CONTRIBUTORS

Engravings of illustrations which have appeared in Volume 29 of the JOURNAL may be purchased by the respective authors or their representatives at one-half cost price. Beginning August 1935, if engravings are not wanted within thirty days from date of publication, they will be destroyed.

Orders to ship engravings to authors should be sent to the editor, from whom cost prices may be obtained. Authors will be billed for purchased engravings plus mailing charges by the business manager of the Association.

This does not apply to engravings for articles for which the costs of publication are paid by authors or their representatives. Such engravings will be shipped to authors at their direction if ordered within thirty days from publications; otherwise they will be destroyed.

JOURNAL
OF ECONOMIC ENTOMOLOGY
Official Organ American Association of Economic Entomologists

Vol. 29 AUGUST 1936 No. 4

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

PAPER-READING SESSION, FORTY-EIGHTH ANNUAL MEETING
St. Louis, Mo., December 1935

BROOD STUDY OF THE CODLING MOTH FOR ONE DECADE[1]

THOMAS J. HEADLEE, *New Jersey Agricultural Experiment Station, New Brunswick*

From the spring of 1926 to the end of the summer season of 1935 continuous records of codling moth emergence at Glassboro, N. J., are available.

Conditions surrounding this study.—The larval collections began usually in the latter part of June or the first of July and continued at weekly intervals until two or more collections had been made in September. The larvae selected were all large and vigorous. Each larva at the time of collection was placed in a small glass vial stoppered with tightly twisted cotton. The vials of each collection were carefully marked and placed on end in a pine box, which was fitted with a screen-wire bottom. These boxes were kept painted white to prevent the absorption of too much sunlight. Two to four boxes of this sort were used and kept suspended from branches of trees in the apple orchard throughout the period of this study. The orchards in which these boxes were suspended were changed from time to time but were always located within about one mile from Glassboro.

These boxes were examined once each week throughout the period when emergence took place and the number of moths emerging in each case was recorded.

Essentially the records submitted are performance of codling moths enclosed in glass bottles stored in these boxes but the results are not to be discounted on that ground because it has been shown (*2*) that they are closely correlated with and accurately represent the same phenomenon in the orchard. There is no doubt that moths begin to emerge earlier from those portions of the tree exposed to maximum sunlight than from the boxes and probably continue somewhat later from those sections of

[1] Paper of the Journal series, New Jersey Agricultural Experiment Station, Department of Entomology.

the tree which are heavily barked and best protected from sunlight, but the maximum emergence (when one-half of the total has emerged) is the same in the orchard as in the boxes. Long experience indicates that in orchards of moderate to light infestation the activity of the early emerging fringe of codling moth is so small as to render it negligible but long experience likewise indicates that in orchards with heavy infestation this early emerging fringe may be a matter of considerable importance and may render cover treatment advisable earlier than it would normally be applied in orchards of less dense infestation.

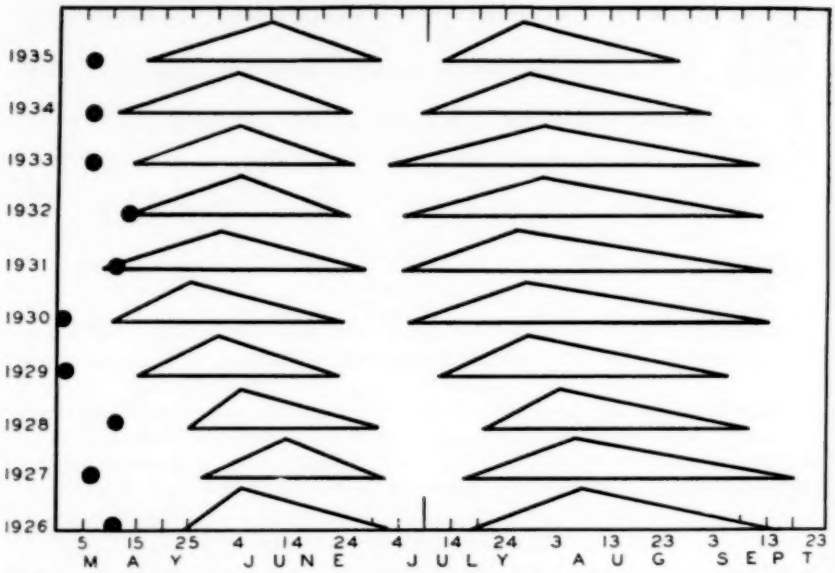

Fig. 1.—Records of 10 years of codling moth broods at Glassboro, N. J. The black dots show the dates of full bloom. The broods are represented by triangles. The left basal angle represents the date on which adults began to emerge, the peak shows the date of maximum emergence, or the time at which half the brood has emerged, and the right basal angle marks the day emergence ceased.

Space does not permit the author to submit the large amount of tabular matter underlying the graphic representation of the results of this study.

Broods of codling moth.—The broods of codling moth, in each of which is shown the beginning, the maximum and the end for the years 1926 to 1935, inclusive, are set forth graphically in fig. 1. Also in this figure is shown the date of average full bloom. Owing to the fact that the data on emergence were taken at weekly intervals it is possible that the emergence began six days before the record is made, that maximum emergence was reached six days before the figure given and that the end of the brood came six days before the record. We must, therefore, at once admit to a possible maximum error of six days in recorded dates. Probably this error

involves a much shorter period but the fact remains that the possible maximum error might be as much as six days.

Figure 1 shows two broods of codling moth in each of the 10 years. Actual breeding tests have proved, and the long active period of the second brood supports the idea, that there is a partial third brood in this two-brooded area. Furthermore, collections of larvae made July 2–9, 1926, and June 28, 1929, show in each case two individuals that pupated and produced moths the year following, indicating a single-brooded condition. It is entirely reasonable that the codling moth population in a

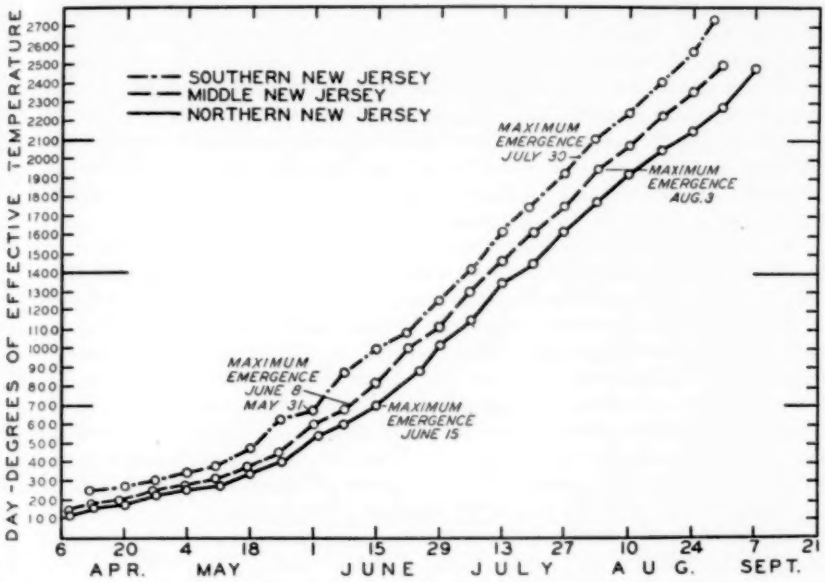

Fig. 2.—Accumulation of day-degrees of effective temperature in 1929 for temperature stations in northern, middle and southern New Jersey, with dates of maximum emergence of adult codling moths. The data are for overwintered and first summer generations, except that absence of a summer generation in northern New Jersey eliminates such data from the curve for that region.

two-brooded area should consist of a limited number of single-brooded individuals, a predominantly large number of two-brooded individuals and a limited number of three-brooded individuals. As the location studied moves to higher north latitude or higher altitudes the single-brooded component of the population increases in number and finally becomes dominant, the double-brooded component decreases in number and finally loses dominance, and the three-brooded contingent decreases in numbers and finally disappears. On the other hand, as the location moves to lower north latitudes or lower altitudes the three-brooded component of the codling moth population increases and finally becomes dominant, the two-brooded contingent decreases in number and loses

dominance and the single-brooded component becomes reduced in number and finally eliminated. As the location moves still further south or into still lower altitudes a fourth-brood component will make its appearance and may, if the location moves far enough, become the dominant component of the codling moth population. In the Glassboro district the overwhelmingly dominant component of the codling moth population is two-brooded but there is evidence of a single-brooded component and ample evidence of a three-brooded component.

Timing of spray applications for codling moth control.—Figure 1 shows a great variation in the period from full bloom to the beginning of overwintered codling moth emergence, ranging in eight of the 10 years from one to 20 days while in two of the 10 years full bloom had occurred after the moths had begun to emerge. The figure also shows that there is great variation in the period from full bloom to maximum emergence of overwintered codling moth, ranging from 18 to 34 days. In view of these large variations in the period of time from full bloom to the occurrence of codling moth activity it seems obvious that the date of full bloom or blossom-fall cannot be used as a satisfactory datum point for dating cover sprays to control codling moth.

A satisfactory datum point for dating cover sprays to control codling moth must undoubtedly be definitely and reasonably constantly related to the periods of codling moth activity. It seems probable that the date of maximum emergence, by which we mean the date on which half of the individuals composing the brood that will emerge have emerged, should bear a distinct relation to the early, maximum and closing activity of the individuals composing the brood. The facts show that the overwintered generation gives rise to worm entry about one week after maximum emergence of moths has taken place and that the first summer generation of moths gives rise to worm entry about the time maximum emergence of the moths has been reached. The facts further show that in orchards of heavy infestation in the two-brooded area of New Jersey the early fringe of emerging overwintered moths may start worm entry from a few days to nearly a week prior to the date of maximum emergence. It is, of course, obvious that a protective cover spray should be established on fruit and foliage just prior to the beginning of worm entry.

MAXIMUM EMERGENCE DATE SELECTED.—These facts seem to indicate that the date of maximum emergence should form a satisfactory datum point for the dating of protective cover sprays for codling moth control. Other methods of dating have been used. For instance, it is possible to apply a cover spray at the blossom fall and repeat this application every week or 10 days until all worm injury ceases. It seems to the writer that this scheme is unduly expensive and likely to result in considerable amounts of spray injury to foliage and fruit where many repeats are employed. For instance, bait-pan records can be taken and cover spraying started as soon as any codling moth appears in the pans. Thereafter, a schedule of weekly or 10-day applications can be carried out until all worm injury ceases. This method is open to almost the same objections as the first method. The logical and scientific method is surely one which relates the time of application of cover sprays to the activity of the insect which

they are designed to control. The only method thus far developed for dating cover sprays in direct relation to codling moth activity is the use of the date of maximum emergence as the datum point for dating the cover sprays. This method has the tremendous advantage of adjusting the treatments to the activity of the insect and of permitting the use of the minimum number of treatments that are necessary to give the control desired.

If we are convinced that the date of maximum emergence is the really satisfactory datum point the question then rises as to how it is to be determined. Various methods have been employed, such as: (1) the maintaining of codling moth emergence cages, adequately representing temperature conditions existing in the orchard, filled with healthy overwintering and also summer generations of larvae, and carefully examined from beginning to completion of emergence of contained insects; (2) maintenance of codling moth cages placed on the tree in such situations as to represent the sunny, medium and shady sides and examined regularly from beginning to the end of emergence; (3) setting up and operating bait pans for catching adult moths and collecting at regular intervals throughout the period of moth catching; (4) setting up and operating temperature stations and the calculation of the thermal constant from the data thus obtained.

USE OF CODLING MOTH-EMERGENCE BOXES.—The codling moth-emergence box, properly constructed and properly placed, gives simple and reliable data for the particular orchard where it is located but requires for its operation experienced background in average percentage of worms that will develop moths under these conditions and must be duplicated in every orchard region or section which is climatically different. In New Jersey the total percentage emerging is about 70, one-half of which comes out in summer and fall collections and the other half the subsequent spring. The disadvantage of this method lies in the time and money required to establish and operate properly such codling moth-emergence boxes. In a rugged region, widely different climatic conditions may obtain within a few miles, necessitating maintenance of a large number of codling moth-emergence boxes.

The codling moth-emergence boxes arranged to represent different sections of the tree merely increase the time and expense involved without in any way materially increasing the accuracy of the timing.

The operation of bait pans shows when moths are on the wing, is highly subject to variable weather conditions and gives no adequate idea of when maximum emergence of adults has occurred or, more especially, is about to occur.

The use of temperature and the thermal constant is an economical and simple way to determine the date of maximum emergence but unfortunately shows too high a degree of variation to be depended upon alone.

The ideal method appears to be composed of a combination of three procedures: (1) location of temperature accumulation stations in a strategic orchard in each climatically different zone as a source of data from which to calculate the accumulation of effective day-degrees of temperature; (2) codling moth-emergence boxes located at a point of maximum

number of broods and density of population as a means of determining the date of maximum emergence; (3) the use of bait pans in the same area with the boxes to evaluate the importance of the early fringe of emerging moths.

MAXIMUM EMERGENCE DATE BASIS OF FLEXIBLE METHOD.—The determination of the date of maximum emergence from properly constructed and properly placed codling moth-emergence boxes gives a reliable datum point from which to date first and later cover sprays. This datum point can be extended to other temperature stations, and thereby to each of the different areas, by plotting the effective day-degrees of temperature

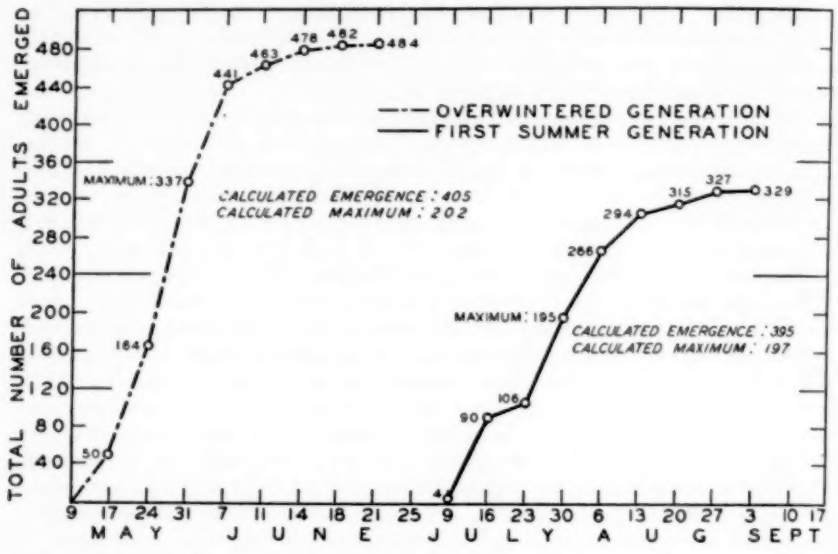

Fig. 3.—Accumulating emergence of adults of overwintered and first summer generations of codling moth in 1929 in the same southern New Jersey orchard for which temperatures are shown in fig. 2. By this means were determined the dates of maximum emergence as set forth on the southern New Jersey temperature curve in fig. 2

accumulating at a box station and at other temperature stations. When the box station has reached the point of maximum emergence there has occurred a certain accumulation of effective day-degrees of temperature. When at the outlying temperature stations this amount of effective day-degrees has been accumulated the period of maximum emergence has been reached at those points. The size of the early fringe of codling moth emergence in the heavily infested orchard of the codling moth-box station can be determined with bait pans and then extended to other heavily infested orchards through the medium of the temperature stations to other sections of the area. With all this information in hand a very shrewd and accurate judgment as to time of cover spraying in each of the different areas can be reached.

The practical operation of the method above outlined is shown in figs. 2 and 3, on which the curves of accumulating effective day-degrees of temperature and of ascertaining codling moth emergence are set forth against time.

The upper, middle and lower curves represent conditions in northern, middle and southern New Jersey in the season of 1929. Maximum emergence of overwintered generation was determined by the use of codling moth-emergence boxes as May 31, 1929, in southern New Jersey. The accumulation of day-degrees of effective temperature at that time and place was 687.74 degrees. This amount of day-degrees of effective temperature was reached in middle New Jersey on June 8, 1929, and in northern New Jersey, June 15, 1929. The date of maximum emergence of the first summer brood was determined by codling moth-emergence boxes in southern New Jersey as of July 30, 1929. The accumulation of effective day-degrees of temperature at that time and place was 1911.56 degrees. This amount of day-degrees of effective temperature was reached in middle New Jersey on August 3, 1929. Since northern New Jersey has only one brood no determination was made for second brood in that section.

Thus the datum point for timing sprays was obtained for northern, middle and southern New Jersey.

Under these 1929 conditions the operator of a heavily infested orchard in the two-brooded area should begin his first cover spray about May 21; the operator of a lightly infested orchard about May 31; the operator of an orchard in the one and a partial second-brooded area about June 8; and the operator of an orchard in the single-brooded area about June 15 or even one week later. Under these conditions an operator of a heavily infested orchard in the two-brooded area should begin the application of his first cover spray for second brood about July 16, the operator of a lightly infested orchard in the two-brooded area about July 23; the operator of an orchard in the first and partial second-brooded area about July 27.

Growers Collect and Forward Data.—Insect materials for the codling moth-emergence boxes are collected the prior season, these collections being made from the latter part of June to the end of September. As rapidly as made, they are placed in the codling moth boxes and examined at weekly intervals throughout the emergence periods of the summer and the subsequent spring. Each temperature station consists of a maximum and minimum thermometer placed on the north side of a post under a selected apple tree. Cards are filed with the grower who makes the readings and records them. Once each week a card carrying the temperatures is sent to the central office for calculation. It has been found that the temperatures of the prior season have apparently no practical effect upon the time of emergence of the moths. Accumulations of temperature, therefore, begin January 1 but very limited amounts of day-degrees of effective temperature accumulate prior to April 1. As the temperatures accumulate week by week they are set forth in curves on a chart, representing accumulation against time. The same thing is done with the codling moth-emergence records which are taken weekly from the boxes.

The trend and rate of accumulation and emergence are thus set up and we have only to extend the curves for a period of generally one week, and never over two, to predict within reasonable limits when maximum emergence will be reached in the boxes and the necessary thermal accumulations for that phenomenon will have occurred. The method above outlined has been in use in New Jersey since 1928 and has given eminently satisfactory and reliable results in timing cover sprays for control of codling moth.—1-23-36.

Literature Cited

(1) **Glenn, P. A.** 1922. Codling moth investigations of the state entomologist's office, 1915, 1916 and 1917. Ill. Natural History Survey Bul. **14**(7):219–89. 8 figs., 7 graphs, 3 charts. Aug.

(2) **Headlee, T. J.** 1928. Some data relative to the relationship of temperature to codling moth activity. Jour. N. Y. Ent. Soc. **36**:147–63.

(3) ———— 1931. Performance of the thermal constant as an indicator of the time to apply cover sprays for codling moth. Jour. Econ. Ent. **24**(1):291–6. Feb.

WHAT IS HAPPENING TO THE CODLING MOTH?[1]

Leonard Haseman, *University of Missouri, Columbia*

As early as 1885 whole crops of apples in some sections of Missouri were reported almost entirely ruined by codling moth, and spraying with London purple and Paris green and the use of tree bands were recommended. The tendency in the past for this pest to vary in importance from time to time is well shown by the fact that by 1889 it was again so scarce that some growers reported it had entirely disappeared. By 1906 the codling moth had spread generally over all the important orcharding sections of the state but up to that time apparently no state-wide losses similar to recent ones had occurred. From 1906 until the late twenties improvements in sprays and spraying equipment and in other orchard practices, stimulated especially by the advent of the San Jose scale, enabled growers to control the codling moth without any serious loss. However, for the last 10 years the codling moth has failed, in this part of the country at least, to follow its normal trends as regards abundance and damage to the apple crop. There have been seasons recently when it seemed utterly impossible to protect the fruit from the pest.

From 1925 through 1933 there was a definite and progressive increase in abundance of codling moth in Missouri, even though there was a decided increase in effort and determination on the part of growers to control it. Why this unheard-of increase, in the face of greatly improved man-made efforts at control? Was the pest undergoing definite evolutionary or physiological changes which made the ordinary control measures ineffective, or were natural checks so much less effective that man's efforts did not produce normal results? Toxicity studies indicated that

[1] Contribution from the Department of Entomology, Missouri Agricultural Experiment Station, Journal series No. 476.

the insect was not developing resistance to the arsenical sprays. Also, more recent developments indicate that it was not undergoing any permanent change which would enable it to continue effectively to resist controls.

Probably we shall never fully understand all the factors that contribute to enable insect pests at times to build up previously unheard-of populations, as was the case recently of the codling moth. However, by analyzing the various factors which may have influenced the earlier increase and the later decline of populations, one is better able to understand what happens when an insect pest suddenly breaks loose and gets beyond control.

In Missouri, orchard management, including the spraying operations, orchard sanitation and neglected packing sheds, was in part responsible for the beginning of trouble. Slowly, populations built up and the percentage of wormy fruit increased without materially reducing orchard profits. Then began the series of years of subnormal rainfall, with some mild winters, which favored further the rapid increase of worm populations. Along with this must be considered the fact that there were practically no crop failures and one or two disastrous bumper crops. At the same time came the hard times with their discouragements and the bewildering residue question. All told, Nature with its favoritism to the pest won out over man's efforts to control it, so that the crop of 1933 in many of Missouri's best orchards looked like a "worm's paradise."

Beginning with the drouth and heat of the midsummer of 1934, however, Nature seemingly repented and turned against the pest. The first brood of worms in 1934 was very heavy and conditions generally were favorable for them. However, the excessive heat and lack of humidity from June until the middle of August were decidedly unfavorable for moth breeding. However, with fall rains and lower temperatures, late worms tended to pick up and we had an abundant carry-over of hibernating worms. The 1934 crop was the first in several years to give many growers much hope that the worm situation would ever be better.

Then came the cold, late, rainy spring of 1935 which held back moth activity to the extent that the fruit crop practically escaped one full brood of worms. When the rains did let up, however, midsummer and early fall conditions rather favored codling moth development, but the pest failed to pick up as in previous years. Orchards which received anything like a satisfactory schedule of sprays were as free of worms as in the years before the recent codling moth unheaval began, although unsprayed blocks showed the usual heavy infestation. Throughout 1935, most Missouri growers continued the use of effective supplementary controls and a heavy schedule of sprays, particularly early in the season. However, spray investigations indicate that this year practically every material used gave fair to good control. Seemingly, conditions made spray coverage more effective in killing worms than at any time in the last eight years.

And still we have the question—what is happening to the codling moth? It built up and with Nature's help got beyond our control. Then with a shift to some unfavorable natural conditions and with the growers

determined to clear the orchards of the pest, we find it at this time well under control in this state. But will it remain under control? With continued good orchard practices and normal season, probably yes, but it will bear watching and fighting strenuously for the next few years.—5-15-36.

LARGE-SCALE TEST OF ORCHARD SANITATION TO CONTROL CODLING MOTH

PROGRESS REPORT

L. F. STEINER and A. J. ACKERMAN, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Orchard sanitation and the use of chemically treated bands are now generally recommended as part of the program for the control of the codling moth, *Carpocapsa pomonella* L. There is, however, a definite need for exact information relative to the benefit that can be expected when such repressive measures are utilized.

In the northwest, Newcomer, Rolfs & Dean (*2*) reported that in a three-year period the use of chemically treated bands permitted an increase of only 72.5 per cent in wormy fruit as compared with an increase of 204 per cent where no bands were used. Their experiment covered only a few acres and did not include a clean-up of ground debris. They and a number of other investigators estimate that bands when properly used will capture 50 per cent or more of the mature larvae.

Chandler (*1*) and Steiner (*3*) have shown that under conditions in the middle west many larvae hibernate in natural and artificial locations under the trees. Bits of bark, wood, weed stems, exposed roots, small shrubs, corn stalks and similar debris offer attractive cocooning quarters. Bands must compete with such ground debris, and inasmuch as a large proportion of the larvae leave apples after they have fallen, the efficiency of the band is certain to be reduced if the larvae come upon satisfactory cocooning quarters before they reach the trunk.

It is the purpose of this report to present the results obtained by the use of chemically treated bands in conjunction with a thorough clean-up in an orchard where sufficient acreage was involved to overcome, at least partially, the effects of adult movement and where the codling moth was extremely abundant.

Experimental set-up and methods.—The experiment was begun in April 1934 and was planned for a period of three or more years. The orchard utilized was a level square block of 40 acres, located near Elberfeld, Ind. The trees were 31 years of age. The varieties were Ben Davis and Collins, set in alternate rows, with occasional replants of Delicious and Stayman. A 35-acre orchard, just coming into bearing, was immediately adjacent on the west. No other orchards were in the vicinity. A well-built packing house was located within one corner of the 40-acre block.

The trees were set 40 by 40 feet, except in a seven-acre section in the

east half of the orchard where the planting distance was 35 feet. The middles were under cultivation, but a 20 by 20-foot square was left untouched under each tree. This grew up each year to thick-stemmed weeds, poison ivy and sassafras sprouts. The trees were in need of pruning. Most of the fruit was produced in clusters on the outer part of the tree. Some dead wood, broken branches, open trunk cavities and split pruning stubs were present.

Spray applications were insufficient in number and were poorly applied; hence, losses caused by the codling moth, the apple flea weevil, *Orchestes pallicornis* Say, bitter rot, blotch and appled scab were excessive.

Early in 1934 PWA funds were available for the initial clean-up of 20 acres. The west half of the orchard, comprising a block of trees 16 rows

Table 1.—Infestation records and control effected by sanitation and banding, Elberfeld, Ind., 1934.

Variety	Treated	Untreated	Difference Favoring Treated Area, Per Cent
	No. Apples per Tree		
Ben Davis	5120	3160	62 increase
Collins	3470	2220	56 increase
			Average 59 increase
	Worm Entrances per 100 Apples		
Ben Davis	78.4	150.4	47.8 reduction
Collins	94.4	147.6	36 reduction
			Average 41.9 reduction
	Worm Entrances per Tree		
Ben Davis	3898	4071	4.2 reduction
Collins	2357	3050	22.7 reduction
			Average 13.5 reduction

wide and 32 long in which the packing house was located, was utilized for the test, and the other half of the orchard was reserved as the control.

The sanitary measures applied included the removal of all surface debris, such as leaves, briers, bark, weeds and shrubs. Because weed stems and bits of wood containing larvae were found in contact with the ground, it was impossible to remove such material without also taking some soil. Dead wood, broken branches, split pruning stubs and all rough bark were removed from the trees. In 1934 all the material was burned in the orchard as it was removed. In 1935 the frequent rains prevented proper burning of ground debris; this was therefore hauled to a point one-half mile from the orchard. The clean-up and scraping was begun on April 19 in 1934 and on March 20 in 1935. The work was completed before spring-brood emergence began.

The packing house was kept sealed during the spring-brood emergence period each year. In 1935 all trunk cavities were covered with fine-mesh wire cloth.

All mature trees in the cleaned area were banded each season with 3-inch beta naphthol bands,[1] with the exception of four rows across the area. Untreated bands were placed on 60 trees in these rows and were

[1] Prepared and supplied by Dr. E. H. Siegler, Bureau of Entomology and Plant Quarantine.

examined at 10-day intervals. Single trunk bands were used in 1934, while the treated bands were applied to both the trunk and the larger scaffold limbs in 1935, after experimental tests had indicated that the total catch could be increased 50 per cent by so doing.

In 1934 the clean-up and banding operations required approximately 2100 hours of labor. Because the trees had not been scraped and no clean-up had been attempted prior to 1934, the initial operations required more time. In 1935, despite delays occasioned by the frequent wetting of ground debris and bark, the time necessary for all operations was reduced to 1300 hours.

The two areas were sprayed alike by the grower. Lead arsenate was

Table 2.—Infestation records and control effected by sanitation and banding, Elberfeld, Ind., 1935.

Variety	Treated		Untreated*		Difference Favoring Treated Area, Per Cent	
	West	East	Whole		Whole	West Half
			No. Apples per Tree			
Ben Davis	2711	1818	2264	1747	29.6 increase	55.2 increase
Collins	3296	2808	3052	2814	8.5 increase	17.1 increase
					Average 19 increase	*36.2 increase*
			Worm Entrances per 100 Apples			
Ben Davis	34.9	49.5	42.2	59	28.5 reduction	40.8 reduction
Collins	19.1	25.4	22.3	68.9	67.6 reduction	72.3 reduction
					Average 48 reduction	*56.6 reduction*
			Injuries (Worms and Stings) per 100 Apples			
Ben Davis	59.6	81.6	70.6	135.1	47.7 reduction	55.9 reduction
Collins	27.8	41.1	34.5	102.9	66.5 reduction	73 reduction
					Average 57.1 reduction	*64.5 reduction*
			Worm Entrances per Tree			
Ben Davis	968	825	896	961	6.8 reduction	.7 increase
Collins	659	702	681	1706	60.1 reduction	61.4 reduction
					Average 33.5 reduction	*30.4 reduction*
			Injuries (Worms and Stings) per Tree			
Ben Davis	1658	1346	1502	2131	29.5 reduction	22.2 reduction
Collins	914	1086	1001	2550	60.7 reduction	64.2 reduction
					Average 45.1 reduction	*43.2 reduction*

* Data from the middle section of seven acres omitted because of the abnormally light crop which resulted from spray injury in the prebloom period.

applied in the petal-fall and four cover sprays each season. In 1935, however, the grower caused severe injury to the middle seven-acre section of the uncleaned area by following a delayed-dormant oil spray too closely with the lime sulfur prepink application. This was followed by a very poor set of fruit, the average yield per tree amounting to 66 per cent less for Collins and 75 per cent less for Ben Davis than the remaining uncleaned area on either side.

Infestation records for the two areas were secured from 74 trees in 1934 and from 80 in 1935. The record trees were distributed uniformly throughout the orchard, being divided equally between the cleaned and the uncleaned area and between the Ben Davis and the Collins varieties. A representative sample of fruit was taken from every tree at each pick-up of drops and at each harvest picking. Because of the heavy infestation, worm entrances only were recorded in 1934, but both worms and stings were counted in 1935.

Results.—The infestation data and related figures are given in tables 1 and 2. Since we are interested primarily in the suppressive effect of sanitary measures and bands, this is best presented by calculating the injuries in numbers per 100 fruits and in numbers per tree, rather than in percentage of fruit injured or clean. Since the number of injuries per 100 apples tends to vary inversely with the size of the crop while the number of injuries per tree tends to vary in direct proportion, both must be considered in measuring the control when the size of the crop differs as much as it does in this experiment.

In 1934 the treated area produced approximately 59 per cent more fruit per tree. In 1935 it averaged approximately 19 per cent more than the 13 acres in the control area not injured by the grower's early sprays. That half of the cleaned area farthest from the untreated trees averaged 36 per cent more fruit. In 1934 the Ben Davis variety produced 47 per cent more fruit in the treated area and 42 per cent more in the untreated area than the Collins. In 1935 the Collins variety produced about 35 cent more in the treated area and 61 per cent more in the untreated area than the Ben Davis. Weather conditions were unfavorable for good pollination of Ben Davis during the blooming period in 1935.

All the evidence indicates that the clean-up measures were responsible for the increased crop in the treated area largely because of their repressive effects on the apple flea weevil. This insect caused severe injury in both areas each season, but the damage was noticeably greater in the uncleaned section.

In 1934 many flea weevils were already feeding when the clean-up began and in 1935 many had emerged from their hibernating quarters in the ground debris before the clean-up could be completed. The early attack was severe enough in the uncleaned area to affect the set of fruit. It appeared lightest in that part of the orchard where the clean-up was completed first. The early removal of the ground debris is also believed to have reduced the amount of apple scab, and this in turn increased the set of fruit. Data to support this belief are lacking.

Because of the influence that crop size has on the codling moth population, only approximate determination of the control effected by the sanitation and banding is possible.

In 1934 the number of entrances per 100 apples for Ben Davis was apparently reduced from 150.4 to 78.4 and for Collins from 147.6 to 94.4. The average reduction was 41.9 per cent. However, because of the difference in numbers of apples, the average worm population per tree was only 13.5 per cent less in the cleaned area. The figure which would represent the true difference must lie between the two percentages given above. It should be noted, however, that the relative codling moth abundance in the two areas before the initial clean-up was unknown. Furthermore, the population around the packing house in the cleaned area at harvest in 1934 was almost as great as the average in the control area. This concentration was the result of a build-up persisting from previous years, probably increased by worms which left apples stacked in the vicinity of the shed during the 1933 harvest. Few if any moths escaped from the sealed packing house in 1934 and 1935. Because of the concen-

tration of fruit at the shed each fall and the probability that many larvae escape before the fruit is placed inside, the infestation there can always be expected to exceed that in the rest of the cleaned area.

In 1935 on Ben Davis the total injuries per 100 fruits and total injuries per tree were respectively 47.7 and 29.5 per cent less in the cleaned area. On Collins there was a reduction of 66.5 per cent in injuries per 100 fruits and 60.7 per cent in injuries per tree. The average of the figures for the two varieties indicates that the reduction in injuries per 100 apples was 57.1 per cent, and in injuries per tree 45.1 per cent. In table 2, separate data for the west half of the cleaned area are also included. The east half, immediately adjacent to the uncleaned area, was subject to more rapid reinfestation from the untreated portion than the west 10-acre half, located eight to 16 rows distant. The latter area had an average of 36 per cent more apples per tree, 56.6 per cent less worms per 100 apples, 64.5 per cent less total injuries per 100 apples, and 43.2 per cent less injuries per tree than the control area.

The actual degree of codling moth control effected by the two-year clean-up and banding operations may therefore be conservatively estimated at 50 per cent. Why it was possible to reduce the number of injuries per tree and per 100 fruits on Collins in 1935 by 60.7 and 66.5 per cent and on Ben Davis by only 29.5 and 47.7 per cent has not yet been determined. The Ben Davis trees in this orchard differed from the Collins in that they had twice as many main scaffold limbs, many of which branched out near the ground. These trees offered many more cocooning places than the Collins and almost twice as much time was required to scrape them. Their low-hanging branches and more abundant cocooning quarters may have lowered the efficiency of the bands.

In 1934 the bands captured 91,000 larvae. This is approximately 10 per cent of the total number which entered fruit in the cleaned area. Because of the heavy third-brood attack in 1934, a large proportion of the larvae were removed from the orchard with the fruit. Natural enemies accounted for many more, and, since hibernating larvae were difficult to find during the 1935 clean-up, the 91,000 captured by bands undoubtedly represented a large proportion of the number which would have survived.

Summary and conclusions.—Sanitary measures which involved a thorough ground clean-up, removal of all rough bark and split branches, and the use of chemically treated bands were applied to half of a 40-acre orchard of 31-year-old apple trees in southern Indiana during 1934 and 1935.

The early destruction or removal of ground debris apparently reduced the injury by the apple flea weevil, *Orchestes pallicornis* Say, and apple scab in the treated area to such an extent that in 1934 this area produced 59 per cent and in 1935 19 per cent more fruit than the uncleaned block.

In 1934 the operations resulted in an average reduction in worms per 100 apples of 41.9 per cent. Only a 13.5 per cent reduction in worms per tree was effected, however, because of the much larger crop.

In 1935 the total injuries per 100 fruits was reduced 47.7 and 66.5 per cent, respectively, for the Ben Davis and Collins varieties, whereas the

reduction in average number of injuries per tree was 29.5 and 60.7 per cent. The average reduction in injuries per 100 apples for both varieties was 57.1 per cent, and for injuries per tree, 45.1 per cent. The 10-acre half of the cleaned area farthest from the uncleaned block had 64.5 per cent fewer injuries per 100 apples and 43.2 per cent fewer injuries per tree.

Control during the second year may be conservatively estimated at 50 per cent.

In 1934 the bands captured 91,000 larvae, which is only 10 per cent of the total number that entered fruit in the area but certainly a much higher percentage of those which normally would have remained in the orchard and completed their life cycle.—7-11-36.

Literature Cited

(1) **Chandler, S. C.** 1928. Codling moth hibernation studies. Jour. Econ. Ent. **21**(2):315–8. Apr.

(2) **Newcomer, E. J., A. R. Rolfs and F. P. Dean.** 1933. A practical test of chemically treated bands for the control of the codling moth. Jour. Econ. Ent. **26**(6): 1056–8. Dec.

(3) **Steiner, L. F.** 1929. Miscellaneous codling moth studies. Jour. Econ. Ent. **22**(4):648–54. Aug.

EIGHT SEASONS' TESTS IN CODLING MOTH CONTROL IN MICHIGAN[1]

Franklin Sherman III, *Michigan State College Agricultural Experiment Station, East Lansing*

The entomology section of the Michigan State College Agricultural Experiment Station has conducted tests and observations on the life history and control of codling moth in several important fruit-growing regions of Michigan. The project was established as a result of heavy losses caused by the progressive increase of this insect during a series of favorable seasons, and the concern of growers following establishment of strict federal tolerances on lead and arsenic despite the lack of proved substitutes.

The procedure has been to secure cooperation of several apple growers in each region. Only orchards that suffered from codling moth were selected. Each plot included from six to 12 trees and in most cases each test was repeated one or more times. All sprays were applied with a standard power sprayer, developing 300–400 pounds of pressure. No certain routine was followed in the applications other than an attempt to obtain adequate coverage.

The work has been prosecuted with the following objectives in mind: yearly tests of careful spraying with lead arsenate, as a base check for other sprays; testing of substitutes for arsenate of lead; closer coordina-

[1] Authorized for publication as Journal article 242, new series, Michigan Agricultural Experiment Station. The project was started by Mr. Louis Gentner in 1928. In 1930 the work was taken over by the writer. This report includes conclusions based upon the entire eight-year period.

tion of the spraying program with habits of codling moth; testing and observation of the value of supplementary control measures.

Tests with lead arsenate.—Before this project was started the general recommendations for codling moth control in Michigan were: the calyx spray, three first-brood cover sprays and one second-brood cover spray. Many growers considered their spraying completed after the single application for the second brood and laid away their equipment in early August. Our tests of 1928–30 indicated that a heavier spraying program was necessary for satisfactory control. Beginning in 1931 our recommendations were for the calyx spray, four first-brood cover sprays, and two or more cover sprays for the second brood. The exact number of second-brood sprays was determined by records from bait-pot traps.

With heavy populations of codling moth poor control was obtained with the former light spraying program. The heavier program adopted in 1931 afforded excellent control. Quick reduction in population and attendant injury was greatly facilitated by supplementary control measures.

Our tests in Michigan with arsenate of lead have clearly demonstrated that this insecticide when used intelligently may be depended upon to control codling moth. Furthermore, experience has shown that without complications caused by the use of stickers and spreaders the residue may be removed without injury to the fruit. Since residue removal is neither expensive nor injurious it is likely that for some years to come lead arsenate will retain its position.

Substitutes for lead arsenate.—The following materials were tested in an attempt to find some substitute for lead arsenate: (1) calcium arsenate, (2) Paris green, (3) magnesium arsenate, (4) zinc arsenate, (5) cuprous cyanide, paste and powder, (6) fluorine compounds, (7) summer oils, (8) orthodichlorobenzene, (9) *Dow-Spray* (organic compound by Dow Chemical Co.), (10) free nicotine–tannic acid, (11) white oil–extract of pyrethrum, and (12) bentonite–nicotine sulfate.

Materials that burned foliage or showed poor control were discarded after a single test while others were tested two or more seasons. For one or more reasons all but three materials have shown little promise as codling moth insecticides. These exceptions are discussed briefly.

Calcium Arsenate.—Calcium arsenate was selected because of its availability, compatibility with lime sulfur, low cost and also because reports from other investigators indicated that it possessed merit. This insecticide did well when tested under light or moderate infestation but was ineffective for severe infestations. The severe foliage injury reported by other investigators has not been experienced. We are convinced that applications must be made more often with this material than with lead arsenate. Calcium arsenate simplifies residue removal by eliminating the lead.

Zinc Arsenate.—This material has been tested three seasons and has proved almost if not quite the equal of lead arsenate in comparative tests. Zinc arsenate eliminates lead residue. It is compatible with lime sulfur and has caused no greater injury to foliage than arsenate of lead. Zinc arsenate has shown decided promise as a substitute for lead arse-

nate and we are suggesting its use in our spraying instructions to growers.

SUMMER OIL–NICOTINE SULFATE.—This combination spray has been tested six seasons. While these tests have not given as consistently good results we are satisfied that this combination when used intelligently affords good protection from codling moth. We are convinced that more frequent applications are necessary than when arsenate of lead or zinc arsenate are used, but for growers who will not wash the fruit and for some early varieties this combination is the best that can be recommended with safety. Needless to say such a program increases the spraying costs considerably.

Coordinating spray program with codling moth habits.—Observations on moth activity included the operation of breeding and emergence cages, bait-pot trapping and observations of pupating larvae beneath untreated bands on trees in the orchards. By utilizing the information obtained from these sources and by frequent examination of the experimental plots throughout the season we were able to judge accurately the time for application. Such data are apparently of great practical use for the timing of spray applications.

Tests and observations on supplementary control measures.—In recent years considerable attention has been devoted to supplementary control measures for codling moth, with much debating as to their value. We recognize that our main dependence must be placed on spraying, but from tests and observations we know that heavy populations may be quickly reduced and more easily controlled when supplementary control measures are practiced. We emphasize scraping and banding, with attention to hibernating larvae in storehouses, packing sheds, cider mills and apple crates which are stored near the orchards. We have evidence which indicates that in Michigan the codling moth is a "one-man bug." Thus, we may find two orchards separated only by a road. In one the control will be excellent; the other, at most only a few rods away, will be eaten up by codling moth. One grower has used intelligently what knowledge and equipment he has, while the other has probably used little of either.—2-14-36.

SUBSTITUTES FOR LEAD ARSENATE IN CODLING MOTH SPRAYS

C. G. VINSON, *University of Missouri, Columbia*[1]

In the fall of 1933 a search was started for suitable substitutes for lead arsenate. Avoidance of lead was the first consideration. Calcium arsenate and iron arsenate were considered. In reviewing the literature it was learned that in general calcium arsenate did not adhere as well as lead arsenate, gave poorer control of the codling moth, but contained more soluble arsenic and hence was more likely to burn foliage and fruit than lead arsenate. Iron arsenate, on the other hand, usually adhered better

[1] Contribution from the Department of Horticulture, Missouri Agricultural Experiment Station, Journal series No. 455.

than calcium arsenate, contained less soluble arsenic than lead arsenate and also gave poorer control of the codling moth. Speculating upon this information, the writer considered the possibility of a complex formation between calcium arsenate and iron arsenate. If a stable complex were obtainable, it might embody the desirable qualities of both the calcium and iron arsenates and at the same time prove good material for controlling the codling moth. According to an analysis of a precipitate, such a complex apparently was obtained. Calcium arsenate in the supernatant liquid was eliminated by decantation, and the precipitate was washed a number of times by elutriation.

During the winter of 1933–34 this precipitated material was resuspended in water and used as a spray on greenhouse plants, including such plants as young tobacco and small peach trees in full leaf. No evidence of spray burn could be detected under these conditions when the material was used at the rate of 1 to 2 pounds of the dry precipitate to 50 gallons of water. Adherence to foliage was good, and no visible injury occurred even on peach leaves under greenhouse conditions.

The results from greenhouse trials led to limited trials of the same material in the orchard during the growing season of 1934. A Collins Red, or Champion, apple tree was sprayed, using the material in the same proportion as lead arsenate was regularly used; namely, 1½ pounds to 50 gallons. Seven sprays in all were applied. As each spray of the new material was applied, a spray of standard lead arsenate was applied to an adjacent tree of Collins Red. Thus both trees received the same number of treatments.

At picking time 3203 apples were harvested from the Collins Red tree which had been sprayed with the new material. Of these, 14.7 per cent showed injury by worms. From the Collins Red tree sprayed with lead arsenate throughout the season, 289 apples were harvested, of which 33.2 per cent had been injured by worms. The number of apples on the last-mentioned tree was so small, of course, that the figures on relative control of worms on the two trees were, perhaps, rendered meaningless. The same number of lead arsenate sprays on various other varieties in the same orchard gave a percentage of apples injured by codling moth larvae varying from 9 to 15.

The spray residue on the fruit sprayed with the new material contained about .021 grain of arsenic trioxide per pound of fruit. A slight amount of lead was present but this may have been partially due to lead arsenate received as spray drift when trees in the vicinity were sprayed. Fruit from the Collins Red tree sprayed with lead arsenate throughout the season contained .028 grain of lead and .013 grain of arsenic trioxide per pound of fruit in the spray residue.

The growing season of 1934 in this part of Missouri (Columbia) was particularly hot and dry from June 20 to August 15. After August 15 to picking time (September 20), about 10 inches of rain fell. There was no appreciable difference in arsenical injury to foliage sprayed with the new material as compared with that sprayed with lead arsenate. The last spray in 1934 was applied July 18.

In the growing season of 1935, beginning May 11, seven sprays of the

arsenical containing iron and calcium were applied to Ben Davis trees. The last spray was applied August 6. The spring of 1935, in this part of Missouri (Columbia), was quite rainy and wet weather prevailed until about July 12. No rain fell from July 24 to about September 1. Arsenical injury to the foliage was quite pronounced. An adhesive substance was added to the spray material which was applied to one Ben Davis tree. At harvest time 44 per cent of the fruit from this tree showed injury from larvae of the codling moth. Two adjacent Ben Davis trees were sprayed with the iron calcium combination without adhesive. At harvest time, 41 per cent of the fruit from these trees had been injured by larvae of the codling moth. Other Ben Davis trees sprayed with lead arsenate showed about 33 per cent of injured fruit due to codling moth.

To avoid objectionable residues on the fruit, many have used nicotine in various combinations. In using nicotine tannate, according to the recommendations of Headlee,[2] difficulty was experienced in obtaining good adherence to the fruit. Nicotine sulfate is considered a good insecticide in general, but its volatility is so great that frequent application of such sprays would be necessary in order to maintain the presence of nicotine and obtain good control of insects. Nicotine belongs to a group of substances known as alkaloids. For this reason Lloyd's alkaloidal reagent was chosen to combine with the nicotine of nicotine sulfate. It seemed probable that the presence of Lloyd's reagent, a siliceous earth, would reduce the volatility of nicotine. Such spray material should exert an insecticidal or else a repellent effect or both over a longer period of time.

During the growing season of 1934, five sprays of the Lloyd's reagent–nicotine combination were applied to a Winesap tree. At picking time this Winesap tree yielded a total of 490 fruits, 18 per cent of which showed injury by larvae of codling moth, whereas only 9 to 15 per cent of fruit from other trees which had been sprayed with standard lead arsenate was injured. One of the main difficulties with the Lloyd's reagent–nicotine combination was in securing good adherence to the foliage. A shower would readily remove the material. Some good sticker or adhesive was needed in this spray material.

Five sprays containing the Lloyd's reagent–nicotine combination were applied to apple trees during the growing season of 1935. A Stayman Winesap tree was sprayed with Lloyd's reagent–nicotine combination only. A Golden Delicious tree was sprayed with the Lloyd's reagent–nicotine combination to which was added a spreading and sticking agent. To another Golden Delicious tree was applied a spray containing the Lloyd's reagent–nicotine combination plus a spreading agent. The last spray was applied in each case August 6.

In spite of the heavy rains during June, it was obvious that where a spreader had been used the Lloyd's was adhering much better than that on the Stayman tree where no spreader was used.

At picking time, from the tree upon which the so-called spreading and sticking agent had been used, 1404 apples were harvested. Of these

[2] **Thomas J. Headlee,** Joseph M. Ginsburg and Robert S. Filmer. 1930. Jour. Econ. Ent. **23**(1): 45–53. Feb.

fruits, 16.6 per cent showed injury from codling moth larvae. Where the other sticking agent was used a total of 3942 apples was harvested, 16.4 per cent of which showed injury from codling moth larvae. Adjacent trees sprayed with standard lead arsenate showed 16.8 per cent of fruit injured by codling moth larvae.

Lead arsenate was used at the rate of 3 pounds to 100 gallons of water. Nicotine sulfate was used at the rate of 1 pint to 100 gallons of water.

Discussion.—Nicotine sulfate is a relatively expensive insecticide. Lloyd's reagent is also quite expensive. Cheaper infusorial earths should be obtainable which are as effective in combination with nicotine as is Lloyd's reagent. Such a spray material, if as effective as lead arsenate, would certainly be most welcome on account of relief from objectionable residue. There may be the possibility of altering the quality of fruits and vegetables by the use of nicotine throughout the season. In these experiments, fruits from trees sprayed with the nicotine combinations throughout the season were certainly not different in quality from other fruits of the same variety sprayed with standard lead arsenate. Much more work remains in order to determine if nicotine may be used with an infusorial earth in some way to control the codling moth. Such a method if, and when, worked out must be as economical as the present operations employed in codling moth control if it is to be accepted by growers.

After the experience of spraying peach and other tender foliage in the greenhouse and after the experience in the field in 1934, the severe burning of foliage with the iron arsenate–calcium arsenate combination was not expected during the season of 1935. The lack of control in 1935 was likewise surprising. However, the variety Collins Red used in 1934 is less subject to codling moth attack and the foliage is more resistant to spray injury than the variety Ben Davis, used in 1935.

Summary.—An iron arsenate–calcium arsenate combination controlled codling moth on Collins Red in 1934 and caused no more arsenical injury than lead arsenate. In 1935, when applied to Ben Davis, it failed to control codling moth and caused severe arsenical injury to the foliage.

Lloyd's reagent with nicotine sulfate did not give as good control of codling moth in 1934 as lead arsenate. Lloyd's reagent with nicotine used with a sticker in 1935 gave approximately as good control as lead arsenate.—5-12-36.

THREE-YEAR STUDY OF CALCIUM ARSENATE FOR CODLING MOTH CONTROL[1]

J. Marshall and Kermit Groves, *State College of Washington, College of Agriculture and Experiment Station, Wenatchee*

Since 1932, codling moth investigations of the Washington experiment station have stressed non-lead arsenical spray mixtures. This course was followed because as far as could be determined the development of suit-

[1] State College of Washington, College of Agriculture and Experiment Station, scientific paper 330.

able organic materials as lead arsenate substitutes would probably be costly and protracted.

A paper from this station was read at the 1935 meeting of the Pacific Slope Branch of the American Association of Economic Entomologists, in which were summarized the results of investigations with calcium arsenate during 1933 and 1934 (*2*). The present paper presents in greater detail certain portions of the work of these two years together with data from the investigations of the past season. All the work was done either at Wenatchee or at Monitor, 10 miles farther up the Wenatchee river valley.

In these districts the average annual precipitation is in the neighborhood of nine inches with practically no rainfall throughout the summer. Codling moth infestation in the various experimental orchards has been from moderate to very severe.

Methods.—Each season six or more cover sprays have been applied; usually four for the first, two for the second brood. Twenty-five-year-old trees capable of bearing 30 boxes of fruit have received 40 to 50 gallons of spray mixture for each application.

Because of the great variability of codling moth infestation in the experimental orchards, numerous check plots were believed essential. In 1933 each experimental plot of six trees immediately adjoined a check plot. Most plots were repeated on a second variety. The arrangement in 1934 on a different orchard was similar with the exception that all treatments were repeated on a second variety. During the past season the larger part of the work was done with one variety, using plots of three trees replicated four times in restricted random arrangement. In this case the check plots were also replicated four times but each set of replicates was repeated seven times, giving a total of 28 check plots.

The extent of the Wenatchee investigations should be mentioned. With a personnel for the past three years of two entomologists, two or three chemists, and generally one or two field assistants, extensive field experiments and much laboratory work have been accomplished. In 1933 the field work required 12 acres of mature trees, bearing some 9000 boxes of apples. In 1934 and again in 1935, 16 acres were utilized. To date, in addition to laboratory experiments with thousands of codling moth eggs and larvae there have been made some 1500 arsenical spray-coverage determinations. About 50 per cent of the work has been in connection with calcium arsenate, of which 45 mixtures have been applied in field experiments and upwards of 100 in the laboratory. The present paper is therefore naturally a very brief and perhaps somewhat inadequate summary of all of the experimental work that has been done.

It is generally difficult to form a reasonable estimate of the effectiveness of experimental mixtures in codling moth insecticide investigations. The writers have preferred to rely for their opinions more upon separate consideration of the major factors suspected of influencing infestation than upon involved statistical methods of analysis. After sampling the fruit from all trees, the average infestation of each experimental plot has been compared to that of the adjoining check plot or an average of all check plots as in the past season's work. Unless it varied from the

check by more than the average deviation from the mean infestation of all checks, any difference was held to be in all probability accidental. On the other hand, differences apparently significant have frequently been ascribed to causes quite apart from the spray mixture. Each year a map has been made for the experimental orchard and codling moth infestation zoned by means of the numerous check plots. These maps used in conjunction with the estimated experimental error calculated as above, have provided a means of judging results which has indicated them reasonably reproducible over the three-year period. Another paper will deal with the experimental methods.

Quantitative as well as qualitative estimation of spray deposits has been considered necessary. In a small chemical laboratory operated in connection with the usual entomological work, arsenical deposits were determined on fruits sampled from the various plots at intervals during the growing season. The analytical procedure described elsewhere (*1*), involved measurement of fruit, calculation of surface area, digestion of discs removed from the cheek of the fruit and determination of arsenic by the bromate method.

Commercial calcium arsenate was used entirely in the experimental work. It has had an arsenic content calculated as As_2O_5, in the neighborhood of 40 per cent, about 45.2 per cent total calcium, and about 4 per cent free calcium hydroxide. The exact percentage of calcium arsenate as tricalcium arsenate is not known.

Results. Calcium Arsenate Alone.—Even in this arid region commercial calcium arsenate used alone in water has caused arsenical injury varying from light to very severe depending upon variety, location of tree, and seasonal conditions. However, where the deposit as total arsenical was maintained equivalent to that of lead arsenate (the arsenic deposit as As_2O_5 being about 30 per cent greater) codling moth control was similar to lead arsenate in 1935. In order to maintain a deposit as heavy as that resulting from the use of 3 pounds lead arsenate, 4 pounds of calcium arsenate have been necessary, though none was removed by rains.

Calcium Arsenate with Protein Spreaders.—Investigations of 1933 indicated that neutral protein spreaders, though improving calcium arsenate coverage from spot to film type, effected little improvement in codling moth control. Arsenical deposit was low and injury inclined to be too severe. Basic protein spreaders were more satisfactory but not suitable from the standpoint of codling moth control.

Calcium Arsenate–Metallic Sulfates–Calcium Hydrate.—It was found that comparatively small quantities (1 pound in 100 gallons) of certain metallic sulfates in the presence of an excess of calcium hydrate were sufficient to prevent arsenical injury. Ferrous sulfate, copper sulfate, aluminium sulfate and zinc sulfate were all effective, but the iron and copper compounds adversely affected codling moth control. Furthermore the copper compound produced a russet condition of the fruit and the iron one interfered with pigmentation. Aluminium sulfate and zinc sulfate seemed similarly satisfactory but in more recent work the zinc compound has been used entirely because it is readily available and in-

expensive, and may be helpful in stimulating the trees, particularly if they show tendency to "little leaf" or "rosette" disorders.

CALCIUM ARSENATE–ZINC SULFATE–CALCIUM HYDRATE.—In 1934 zinc sulfate was used in varying amounts with calcium arsenate and calcium hydrate. While even one-fourth pound zinc sulfate ($ZnSO_4 \cdot 7H_2O$) was apparently sufficient to prevent arsenical injury if in the presence of an excess of calcium hydrate the deposit was spotted. One pound of the sulfate used with 2 pounds of calcium hydrate has generally resulted in a film deposit and doubtless provides a greater margin of safety than the smaller amount with no apparent decrease in effectiveness. Table 1 gives results from the latter type of mixture over a three-year period.

Table 1.—Arsenic deposit and codling moth infestation with use of calcium arsenate–zinc sulfate–calcium hydrate.

YEAR	AMOUNTS PER 100 GALLONS WATER	APPLE VARIETY	DEPOSIT*	LARVAE PER 100 FRUITS
1933	Calcium arsenate 3 lbs., zinc sulfate 1 lb.			
	Calcium hydrate 2 lbs.	Jonathan	17.2	30
	Lead arsenate 3 lbs. (check adjoining)	Jonathan	24.4	27.3
	Average deviation of 5 checks from mean	Jonathan		±1.9
1934	Calcium arsenate 3 lbs.	Jonathan	20.8	4.4
	Lead arsenate 3 lbs. (check adjoining)	Jonathan	20.5	7.2
	Average deviation of 15 checks from mean	Jonathan	±.6	±3.1
1934	Calcium arsenate 3 lbs.	Rome Beauty		75.4
	Lead arsenate 3 lbs. (check adjoining)	Rome Beauty		54.4
	Average deviation of 15 checks from mean	Rome Beauty		±11.1
1935	Calcium arsenate 4 lbs., zinc sulfate 1 lb.			
	Calcium hydrate 2 lbs.	Rome Beauty	13.4	62.3
	Lead arsenate 3 lbs., herring oil ⅛%† (Check)‡	Rome Beauty	14.2	80.8
	Average deviation of 7 checks from mean	Rome Beauty	±.8	±22.2
1935	Calcium arsenate 4 lbs., zinc sulfate 1 lb.			
	Calcium hydrate 2 lbs.	Stayman-Winesap**	20.8	10.2
	Lead arsenate 3 lbs., herring oil ⅛% (check)‡	Stayman-Winesap	18.2	12.2
	Average deviation of 6 checks from mean	Stayman-Winesap	±1	±3.2

* Deposit as micrograms As_2O_3 per square centimeter on cheek of fruit. Average of four to five duplicated analyses. In 1933 a "stripping" method was followed with results not as satisfactory as in 1934 and 1935 when fruit was "disced."

† Containing 5 per cent by volume added oleic acid.

‡ Average of all checks each of which was made up of four replicates.

** Single trees duplicated. Infestation results less reliable than any of the others but deposit data adequate.

In one case, Jonathan (1934), the difference in infestation between plots sprayed with the calcium arsenate–zinc sulfate–calcium hydrate mixture and the checks sprayed with lead arsenate alone was in favor of the calcium arsenate mixture and greater than the average deviation from the mean infestation of the check plots. In two cases, Rome and Stayman-Winesap (1935), the differences were in favor of the calcium arsenate mixture but less than the deviation from the mean infestation of the checks. On Jonathan (1933) the difference was in favor of the lead arsenate check but less than the average check deviation. On Rome (1934) the difference was in favor of the check and was considerably greater than the average check deviation.

The fact that the average calcium arsenate deposit appeared to be maintained at a fairly high level was due to the analyses made immediately after spraying having been relatively high though those made a month or more after spraying were low. This is exemplified in the work of the past season. Immediately following the sixth and last cover spray on Romes, the average deposit on seven lead arsenate–herring oil check plots was 19 micrograms As_2O_3 per square centimeter. That on the calcium arsenate–zinc sulfate–calcium hydrate was 17.6 micrograms, or 7.3 per cent less. At harvest the checks showed 14.9 micrograms, the calcium arsenate mixture 10.7 micrograms, 28.1 per cent less despite the fact that during the intervening five-week period there was but a single gentle rainfall. Incidentally it appears to be more difficult to maintain a satisfactory spray deposit of any type on Romes than on the other commercially grown varieties in north-central Washington.

Favorable results from this type of calcium arsenate mixture have been most readily obtained with varieties which are either picked early in the season (Jonathan) or which though not susceptible to late infestation may be susceptible to first-brood attack (Stayman and Winesap). But its possible inferiority on late-picked varieties susceptible to second and third-brood attack seems to depend more largely upon its lack of adhesiveness than upon lower toxicity compared to lead arsenate. Even on Romes it will be noted that in 1935, when the fruit was picked considerably earlier than usual, the calcium arsenate mixture gave results which appeared quite as satisfactory as lead arsenate–herring oil mixture, though the arsenical deposit as maintained throughout the season was no greater. In order to preserve this deposit it was necessary to use one-third more arsenical, *i.e.*, 4 pounds instead of 3.

The cost of 100 gallons of spray, using 3 pounds of lead arsenate and 1 pint herring oil was practically the same as that of the calcium arsenate–zinc sulfate–calcium hydrate mixture, using 4:1:2 pounds.

Evidence so far obtained suggests that in the less heavily infested areas of this district where effective control of the codling moth has been accomplished by applications of lead arsenate alone or with ordinary spreaders, a calcium arsenate 4:2:1 mixture should give equivalent results. As matter of fact, during the past season practical trials of it were carried out by five growers on about 12 acres under such conditions. Results were in each case satisfactory.

CALCIUM ARSENATE–PETROLEUM OIL.—In the first year of the investi-

gations, combination of any of a number of vegetable or animal oils with calcium arsenate occasioned very severe arsenical injury, even the terminal growth being killed. However, it was observed that no such deleterious effects occurred when petroleum oil was used with calcium arsenate. Indeed there was less arsenical injury where one-half per cent petroleum oil was used than where the arsenical was applied with a neutral spreader

Table 2.—Arsenic deposit and codling moth infestation with use of calcium arsenate–medium summer oil, one-half per cent.

Year	Amounts per 100 Gallons Water	Apple Variety	Deposit*	Larvae per 100 Fruits
1933	Calcium arsenate 3 lbs., oil ½%†	Jonathan		14.1
	Lead arsenate 3 lbs. (check adjoining)	Jonathan		23.4
	Average deviation of 5 checks from mean	Jonathan		±1.9
	Calcium arsenate 3 lbs., oil ½%	Rome Beauty	24.1	7.9
	Lead arsenate 3 lbs. (check adjoining)	Rome Beauty	20.7	16.4
	Average deviation of 4 checks from mean	Rome Beauty		±1.5
1934	Calcium arsenate 3 lbs., oil ½%	Jonathan	40.1	4.1
	Lead arsenate 3 lbs. (check adjoining)	Jonathan	19.5	8.4
	Average deviation of 15 checks from mean	Jonathan	±.6	±3.1
	Calcium arsenate 3 lbs., oil ½%	Rome Beauty		21.5
	Lead arsenate 3 lbs. (check adjoining)	Rome Beauty		38.5
	Average deviation of 15 checks from mean	Rome Beauty		±11.1
1935	Calcium arsenate 4 lbs., oil ½%	Rome Beauty	22.4	59.1
	Lead arsenate 3 lbs., herring oil ¼% (check)‡	Rome Beauty	14.2	80.8
	Average deviation of 7 checks from mean	Rome Beauty	±.8	±22.2
	Calcium arsenate 4 lbs., oil ½%	Stayman-Winesap	28.4	6.5
	Lead arsenate 3 lbs., herring oil ¼% (check)‡	Stayman-Winesap	18.2	12.2
	Average deviation of 6 checks from mean	Stayman-Winesap	±1	±3.2

* Deposit as micrograms As_2O_3 per square centimeter on cheek of fruit. Average of four to five duplicated analyses. In 1933 a "stripping" method was followed with results not as satisfactory as in 1934 and 1935 when the fruit was "disced."

† Emulsified with ammonium caseinate.

‡ Average of all checks, each of which was replicated four times.

and no more than with lead arsenate used alone. Subsequent experiments in 1934 and 1935 with the same type of oil confirmed this. The oil was medium grade with viscosity of 70–75 seconds Saybolt at 37.8° C and an unsulfonatable residue of 90 per cent.

During the past season one-fourth per cent of this oil reduced arsenical injury as compared to calcium arsenate applied alone. Nevertheless not only one-fourth but one-half per cent was less effective in preventing

injury than even the weakest of the zinc sulfate combinations already discussed. When a less highly refined petroleum oil (57 per cent unsulfonatable) was used with calcium arsenate considerable foliage injury was observed. It appeared to be largely of arsenical nature.

Table 2 concerns the use of medium summer oil at one-half per cent with calcium arsenate in all cover sprays, a combination which has been used each of the three years.

Addition of one-half per cent petroleum oil to 3 pounds of calcium arsenate has resulted in codling moth control which was for two years on Jonathans and two years on Romes from 40 to 50 per cent better than lead arsenate alone at 3 pounds. The third year its addition to 4 pounds of calcium arsenate gave control 26 per cent better on Romes and 46 per cent on Stayman-Winesap than lead arsenate at 3 pounds with one-eighth per cent herring oil. With one exception the improvements in control were practically twice as great as the estimated experimental error.

Experiments of the 1935 season included plots sprayed throughout with the addition of one-half per cent ammonium caseinate–petroleum-oil emulsion to three pounds of lead arsenate, which were comparable to those, table 2, of 1935, sprayed with calcium arsenate and petroleum oil. The increase in deposit with the lead arsenate–oil was 25 per cent on Romes and 30 per cent on Stayman-Winesap, as compared to the average of the check plots. The improvement in control was 46 per cent in each case, fairly comparable to that from four pounds of calcium arsenate with the same amount of added mineral oil. However, the deposit increase as As_2O_3 was about twice as great in the case of the calcium arsenate mixture, 57 per cent and 56 per cent on Romes and Winesaps respectively; thus it might appear that the calcium arsenate–oil mixture was less efficient than the lead arsenate–oil. From the standpoint of arsenic content this might be so but from that of total arsenical, *i.e.*, calcium arsenate deposit compared to lead arsenate, the increase was but 17 to 18 per cent compared to 25 to 30 per cent for the lead arsenate, due to the greater arsenic content of the calcium compound. Calcium arsenate was evidently as effective as lead arsenate where it adhered as well.

A difficulty with the calcium arsenate–petroleum-oil mixture has been that it produces an uneven spotted deposit. Such a deposit is not only less effective than one in the form of a good film but likewise may interfere with uniform pigmentation of the fruit. In 1934 there were reported from this station certain experiments (*3*) which resulted in a lead arsenate–oil mixture characterized by deposits of unusual uniformity and extraordinary amount. The peculiar qualities of this mixture are dependent on the maintenance of a particular ratio between the amounts of its constituents, lead arsenate, oil and triethanolamine oleate. A number of soaplike substances, such as sulfated higher alcohols, were tried as substitutes for the triethanolamine soap but none gave comparable results. However, though certain organic soaps may be applied with acid lead arsenate and petroleum oil they cannot be applied with calcium arsenate alone because of formation of insoluble calcium soap and consequent breaking of the emulsion.

For some time efforts to duplicate the uniformly heavy coverage of this lead arsenate mixture with calcium arsenate were unsuccessful. As with lead arsenate, certain soaplike compounds were used with calcium arsenate and oil but though they were compatible poor deposits resulted. Eventually, it was determined that such soaps as triethanolamine oleate may be used with calcium arsenate providing the free calcium hydroxide be removed by the addition of just enough zinc sulfate for the purpose. This may prevent the formation of a calcium soap, though it seems more probable that it prevents the agglutination of the small particles of metallic soap. During the past summer, second-brood spray treatments of such a combination (calcium arsenate–zinc sulfate–petroleum oil–triethanolamine oleate) were applied to Stayman and Winesap trees. Though deposits were uniformly filmed and were 125 per cent greater than those of the lead arsenate–herring-oil checks, no arsenical injury appeared. On the other hand, arsenical injury was plainly evident on the

Table 3.—Arsenic deposit and codling moth infestation, using calcium arsenate with varying amounts of medium petroleum oil. Rome Beauty apples, 1935.

Amounts per 100 Gallons Water	Deposit*	Larvae per 100 Fruits
Calcium arsenate 4 lbs.	18.8	82.5
Calcium arsenate 4 lbs., oil ¼%†	21.7	81.2
Calcium arsenate 4 lbs., oil ½%	22.4	59.1
Calcium arsenate 4 lbs., oil 1%	28	40.8
Lead arsenate 3 lbs., herring oil ⅛% (check)‡	14.2	80.8
Average deviation of 7 checks from mean	± .8	±22.2

* Deposit as micrograms As_2O_3 per square centimeter on cheek of fruit. Average of four to five duplicated analyses. In 1933 a "stripping" method was followed with results not as satisfactory as in 1934 and 1935 when the fruit was "disced."

† Ammonium caseinate emulsions.

‡ An average of seven checks, each consisting of four replicates of three trees, as for the experimental mixtures.

check trees. Codling moth control with this mixture appeared to be about as greatly improved over the checks as might reasonably be expected from the higher and more uniform deposit.

Although investigation of calcium arsenate–soap–oil mixture is in its preliminary stages, the results have thus far been gratifying. The principal difficulty with these new combinations, whether of lead or calcium arsenate, appears to lie in the rather narrow balance necessary between the amounts of the various constituents and consequent breaking of the emulsion or poor deposition should there be present excessive or insufficient amounts of any of them. In addition they show varying tendencies to instability of emulsion if overflow is excessive.

Attention has been paid to the effect of varying amounts of petroleum oil upon deposition of calcium arsenate. Table 3 shows the results of adding one-fourth to 1 per cent medium summer oil in all applications.

The deposit of calcium arsenate increased when one-fourth per cent oil was added, and as the amount of oil was raised from one-fourth to one per cent the increase became more evident. This has not been noted to the same extent with lead arsenate when combined with ammonium caseinate emulsion of petroleum oil. Although one-half per cent oil produced deposits little heavier than one-fourth per cent, codling moth

control was better. Evidently the greater ovicidal effect of the larger amount of oil influenced the infestation.

As expected, the use of 1 per cent of the mineral oil resulted in distinctly better codling moth control than the smaller amounts. Here a very heavy deposit and high ovicidal value together came into play. Such a large amount of oil continually applied is too injurious to apple foliage to be employed in practice.

In addition to variations in the amount of medium petroleum oil used with calcium arsenate, experiments were undertaken with oils of different sulfonation values and different viscosities. Reference has already been made to the occurrence of injury following the use of an oil of 57 per cent unsulfonatable residue. Since similar injury did not occur with lead arsenate it is assumed that it was caused at least largely by soluble arsenic. Evidently a highly refined oil with at least 90 per cent unsulfonatable residue is desirable for use with calcium arsenate.

Table 4.—Arsenic deposit and codling moth infestation, using calcium arsenate with petroleum oils of different viscosities. Rome Beauty apples, 1935.

Amounts per 100 Gallons Water	Deposit*	Larvae per 100 Fruits
Calcium arsenate 4 lbs.	18.8	82.5
Calcium arsenate 4 lbs., medium oil ¼%†	21.7	81.2
Calcium arsenate 4 lbs., heavy oil ¼%	25.7	54.3
Lead arsenate 3 lbs., herring oil ¼% (check)‡	14.2	80.8
Average deviation of 7 checks from mean	± .8	±22.2

* Deposit as micrograms As_2O_3 per square centimeter on cheek of fruit. Average of four to five duplicated analyses. In 1933 a "stripping" method was followed with results not as satisfactory as in 1934 and 1935 when the fruit was "disced."

† Ammonium caseinate emulsions.

‡ An average of seven checks, each consisting of four replicates of three trees.

As for viscosity, an oil of 121 seconds Saybolt (37.8° C) and 98 per cent unsulfonatable residue was compared at one-fourth per cent to the medium oil already mentioned (73 seconds viscosity and 90 per cent unsulfonatable residue). Results are in table 4.

The heavier oil considerably increased deposition of the calcium arsenate and this was reflected in improved codling moth control. Both in deposit and control the differences were greater than the average deviation of the check plots. Similar results were obtained on Stayman-Winesap in the smaller experimental orchard.

Calcium Arsenate–Zinc Sulfate–Calcium Hydrate–Petroleum Oil.—Although medium summer petroleum oil at one-half per cent has for three consecutive years prevented serious arsenical injury from calcium arsenate, it is suspected that the margin of safety would not be sufficiently great in a season of unusually heavy precipitation. In 1934 petroleum oil at one-half per cent was used with calcium arsenate alone as well as with added zinc sulfate and calcium hydrate. One plot received one-fourth pound zinc sulfate and one-half pound calcium hydrate, the other 1 pound of zinc sulfate and 2 pounds of calcium hydrate. The appearance of the trees in both plots was similarly satisfactory, and so in 1935 addition of the smaller amounts was investigated further.

Apparently the addition of one-fourth pound zinc sulfate and one-half

pound calcium hydrate to calcium arsenate–petroleum oil (ammonium caseinate emulsion) did not significantly lower either arsenical deposit or codling moth control. The only large variation occurred in the deposit on Jonathan in 1934. An increase of 105 per cent in deposit was, for that

Table 5.—Arsenic deposit and codling moth infestation, using calcium arsenate–zinc sulfate–calcium hydrate–medium petroleum oil.

Year	Amounts per 100 Gallons Water	Apple Variety	Deposit*	Larvae per 100 Fruits
1934	Calcium arsenate 3 lbs., oil ½%	Jonathan	40.1	4.1
	Lead arsenate 3 lbs. (adjoining check)	Jonathan	19.5	8.4
	Calcium arsenate 3 lbs., oil ½%, zinc sulfate ¼ lb., calcium hydrate ½ lb.	Jonathan	33.7†	6.6
	Lead arsenate 3 lbs. (adjoining check)	Jonathan	20.5†	16.7
	Average deviation of 15 checks from mean	Jonathan	±.6	±3.1
	Calcium arsenate 3 lbs., oil ½%	Rome Beauty		21.5
	Lead arsenate 3 lbs. (adjoining check)	Rome Beauty		38.5
	Calcium arsenate 3 lbs., oil ½%, zinc sulfate ¼ lb., calcium hydrate ½ lb.	Rome Beauty		24.1
	Lead arsenate 3 lbs. (adjoining check)	Rome Beauty		44.8
	Average deviation of 15 checks from mean	Rome Beauty		±11.1
1935	Calcium arsenate 4 lbs., oil ½%	Rome Beauty	22.4	59.1
	Calcium arsenate 4 lbs., oil ½% zinc sulfate ¼ lb., calcium hydrate ½ lb.	Rome Beauty	23	53.1
	Lead arsenate 3 lbs., herring oil ⅛% (check)‡	Rome Beauty	14.2	80.8
	Average deviation of 7 checks from mean	Rome Beauty	±.8	±22.2
1935	Calcium arsenate 4 lbs., oil ½%	Stayman-Winesap	28.4	6.5
	Calcium arsenate 4 lbs., oil ½% zinc sulfate ¼ lb., calcium hydrate ½ lb.	Stayman-Winesap	28.1	3.7
	Lead arsenate 3 lbs., herring oil ⅛% (check)	Stayman-Winesap	18.2	12.2
	Average deviation of 6 checks from mean	Stayman-Winesap	±1	±3.2

* Deposit as micrograms As_2O_3 per square centimeter on cheek of fruit. Average of four to five duplicated analyses. In 1933 a "stripping" method was followed with results not as satisfactory as in 1934 and 1935 when the fruit was "disced."

† Average of only three analyses.

‡ An average of seven checks, each consisting of four replicates of three trees.

year and considering all plots, somewhat out of line. It was largely due to a single analysis being exceedingly high and there seems no satisfactory explanation for the irregularity. In spite of the apparently greater deposit, codling moth control appeared no better than on the plot receiving the added zinc sulfate–calcium hydrate.

Injury from calcium arsenate.—The main points concerning the occurrence of injury to foliage or fruit following the application of calcium arsenate sprays have already been mentioned. With additional observations, they are summarized here.

In the arid Wenatchee-Okanogan district calcium arsenate used alone has caused severe arsenical foliage injury. The addition of neutral protein spreader did little to lessen injury but spreader containing free hydrated lime reduced it somewhat. An excess of hydrated lime (6 pounds in 100 gallons) completely prevented injury though resulting in markedly increased infestation.

Animal and vegetable oils used with calcium arsenate resulted in very severe injury to foliage, fruit and terminal growth. When used in the presence of a great excess of hydrated lime no injury occurred but codling moth control was inferior.

One-half per cent petroleum oil of 57 per cent unsulfonatable residue with calcium arsenate resulted in considerable injury which appeared to be arsenical, but medium oil of 90 per cent unsulfonatable residue largely prevented arsenical injury at one-fourth to one-half per cent. Addition of one-fourth pound zinc sulfate and one-half pound calcium hydrate to the oil–calcium arsenate, prevented arsenical injury. The combination of 3 or 4 pounds of calcium arsenate with 1 pound zinc sulfate and 2 pounds of hydrated lime has produced no sign of arsenical injury though injury has been common with lead arsenate used alone. This mixture appears to have a stimulative effect upon apple trees of central Washington, at least under certain conditions.

In 1933 seven brands of calcium arsenate were applied with herring oil on Romes. All caused severe injury.

Residue removal.—Investigation of residue removal with calcium arsenate mixtures will be reported elsewhere by the departments of horticulture and chemistry of this station. It may be said here that it is evidently an easier problem to meet the arsenic tolerance where calcium arsenate has been used, then to meet the lead tolerance where lead arsenate has been similarly used.

Summary.—For the last three years certain calcium arsenate mixtures have been successfully used in experimental work in spraying for codling mother control in the arid Wenatchee valley of Washington. Their effectiveness has been judged from comparison with lead arsenate used alone or with the addition of herring oil.

Where equal or greater deposits of calcium arsenate have been maintained codling moth control has compared favorably with that in which lead arsenate used alone or with herring oil. However, without added petroleum oils it has been more difficult to maintain a satisfactory deposit with calcium arsenate than with lead arsenate.

Calcium arsenate alone has resulted in severe injury but the addition of small amounts of zinc sulfate and calcium hydrate has remedied the difficulty.

Animal and vegetable oils with calcium arsenate have caused exceedingly severe arsenical injury.

Highly refined petroleum oil has largely prevented arsenical injury

when applied with calcium arsenate. It has also increased the arsenical deposit and improved codling moth control.

Heavy petroleum oil produced a greater arsenical deposit and better codling moth control than medium oil.

Petroleum oil of low unsulfonatable residue has not been satisfactory with calcium arsenate.

Addition of small amounts of zinc sulfate and calcium hydrate to calcium arsenate–petroleum oil has appeared advisable in order to provide a suitable margin of safety from arsenical injury.

Ammonium caseinate (paste) emulsion of petroleum oil used with calcium arsenate has resulted in an undesirable spotted deposit of arsenical. It has been found possible to avoid this, at the same time increasing the deposit, through the use of an organic soap emulsion of oil in the presence of a small amount of zinc sulfate. Investigation of this type of mixture is still in the preliminary stage.

Residue removal with calcium arsenate has not been as difficult as with lead arsenate similarly used.

At present it appears that in districts with little or no summer rainfall commercial calcium arsenate may be substituted for lead arsenate in codling moth control providing certain substances are added. Any grower wishing to try a calcium arsenate mixture should at first do so only in a limited way.

The cost of suitable calcium arsenate spray mixtures has been fairly similar to that of lead arsenate mixtures.—7-14-36.

Literature Cited

(1) **Groves, Kermit** and J. Marshall. 1935. The determination of spray coverage on apples. Jour. Ag. Res. **51**(12): 1139–42.

(2) **Marshall, James,** 1935. The experimental application of calcium arsenate for codling moth control in an arid region. Jour. Econ. Ent. **28**(6): 960–5. Bibliog. Dec.

(3) **Marshall, J.,** P. M. Eide and A. E. Priest. 1934. Increasing and maintaining lead arsenate deposits for codling moth control. Proc. Wash. State Hort. Assn. 52–64.

NEW METHOD OF CODLING MOTH CONTROL IN THEORY AND PRACTICE

G. E. Marshall, *Purdue University Agricultural Experiment Station,*[1] *Lafayette, Ind.*

Research and extension agencies have a twofold obligation to agriculture: first, proving the merit of new practices, and second, inducing growers to adopt them. None of the several proved methods of timing codling moth sprays has been generally incorporated into the programs of orchardists. The program herein suggested offers in theory and the experience of two years' practice a simplified method of codling moth control, which if tests continue to prove it effective, should be more readily accepted by apple growers.

[1] Contribution from the Department of Entomology.

Trees tolerate more early season sprays.—Bait traps, bands and other methods used to time sprays do not always indicate the earliest moth flight and more than one cover spray is necessary to insure complete coverage of apple fruit and foliage and so to prevent the entrance of the first larvae, which are potentially many times more dangerous than even late first-brood worms. If, then, sprays could be applied in commercial orchards, having as the objective prevention of any entrances before June 20, the emergence and subsequent hatch would amount to but very little. This is true because bait trap records over a period of three years show that in southern Indiana all but less than 1 per cent of the codling moth adults from the spring brood emerge before June 20. Results of our 1935 spraying studies indicate that apple trees will tolerate the necessary spray materials when applied more frequently and over a shorter period early in the season (first cover-spray period) with no more injury than when the applications cover a longer period (first and second-brood cover-spray period).

With normal activity the less than 1 per cent of the first brood hatching after June 20 could not produce a destructive third brood. Therefore, if spraying is discontinued after June 20, there will be a good cover of material that would remain effective over a considerable period, inasmuch as the same rapid weekly area increase, so noticeable during May and the first half of June, would not continue. From this time till harvest, with no more spraying, a considerable amount of the residue would gradually weather off. The situation thus described would be dependent on absence of any heavy infestations in adjacent orchards.

The prevention of practically all entries till after June 20 would necessitate thorough and heavy applications made to the inside and outside of the trees beginning seven days after the calyx spray, as practiced in 1935. The second cover should come seven to 10 days after the beginning of the first and so on till four or five covers have been applied before June 20. There need be no timing, no variation in the amount of summer oil used after lime sulfur is discontinued, which is usually the second cover spray, and at present no concern as to the possibility of difficulties in the residue removal if efficient washing methods are employed.

Program correlates insect and disease control.—Such a program fits in admirably with the control of other insects, as well as blotch, fire blight, bitter rot and other diseases. In the case of scab such a program is an improvement over the old spray schedule for the reason that growers often have to make additional applications for this disease.

For the last two years this program has been used in southern Indiana where three broods of codling moth normally occur. The spray materials used were lead arsenate, summer oil and soap, with special attention given to the hardness of the water, since this determines the amount of soap to be added to the water for best results.

Changes in the amount of soap to be added where certain strengths of Bordeaux or lime sulfur are used must likewise be given consideration. It should be noted that soap may be used with both these fungicides with excellent results. The amount of oil used is also a factor in determining the amount of soap to include. Although to date several experi-

ment station workers have reported poor to very poor results with this combination, its use in Indiana commercially and in field plots for the last two years indicates that a study of the amount of soap to add is a most important point in the success of this combination. This is also the opinion of Eddy, formerly of Kentucky, who has been doing much work with spreaders and stickers. In the northwest, soap and lead arsenate have been widely used but without summer oil.

Method demonstrates effective control.—In 1934, replicated plots of this combination on Grimes and Winesaps reduced the infestation from more than 125 worms per 100 apples in 1933 to 1.63 worms per 100 in 1934. The lead–lime check in 1934 showed that 650 attempted entrances had been made per 100 apples.

In 1935 an eight-acre orchard which had been a commercial failure because of codling moth since 1928 was sprayed with the lead arsenate, summer oil and soap combination by the method already described. Infestation of that orchard for the last six years has been as follows:

1929—67.5 worms and 108 stings per 100 apples
1930—45 worms and 29 stings per 100 apples
1931—33 worms and 43 stings per 100 apples
1932—85 worms and 125 stings per 100 apples
1933—93 worms and 231 stings per 100 apples
1934—65–95 worms and 150 stings per 100 apples
1935—1.3 worms and 4 stings per 100 apples

Such a reduction from 95 worms and 150 stings per 100 apples in 1934 to 1.3 worms and 4 stings per 100 apples in 1935 might be attributed to a sequence of natural ecological conditions were it not for the fact that lead–lime checks in the same orchard showed an infestation at harvest of 35 worms per 100 apples. In 1935 half of the Purdue orchard at Bedford, or 40 acres, was sprayed in a commercial manner with this combination, as was 10 acres of the Troth orchard at Orleans, with excellent results.—6-23-36.

THE PERIODICAL CICADA

J. A. Hyslop, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Entomologists have been so zealous in attempting to dispel the alarm occasioned by newspaper accounts of the devastation wrought by the periodical cicada, *Magicicada septendecim* (L.), that they have created in the minds of their associates a quite erroneous idea that this insect is of scarcely any economic importance. This is decidedly understating the facts. The periodical cicada is an important insect pest. There are records of young orchards being completely destroyed and of the fruit crop of mature orchards being practically eliminated the year following an outbreak. It is known that the scars made by these insects in ovipositing afford excellent hibernating places and places of concealment for aphids, coccids, white flies and other insects, and these wounds probably afford

good opportunity for the entrance of plant diseases. It is true that the insect is of economic importance only in limited areas where the plants attacked are in the immediate vicinity of woodland or on land that has recently been reclaimed from the forest, and that much of the alarm is unwarranted.

Few entomologists are willing to attempt an investigation that cannot bear fruit until 17 years have passed. Our information on the periodical cicada is deplorably scanty. The insect has been known on the North American continent for over 200 years, and has attracted the attention of entomologists for over 100 years, yet many of the most fundamental facts of its life history and habits are still unknown. In reading any account of this insect one is struck by the uncertainty that permeates it. "It is believed," "It is said," "We can naturally infer," and such expressions appear in almost every paragraph.

We will not suggest that any particular entomologist set up a project on this insect to be continuous for 17 years, desirable as this might be, but much could be done by a concerted effort on the part of every entomologist living within the range of the periodical cicada to make such observations as are possible at the time of each appearance of the broods in his immediate vicinity.

Even the geographical distribution of this insect, which has probably been more completely recorded than any phase of its biology, is very inadequately known. If every entomologist would feel it his duty to the profession to put forth an effort to record every locality and verify every report of the occurrence of this insect within his territory every time a brood appears, this phase of the work would soon be completed. The Insect Pest Survey is attempting to assist in this work by writing to the official entomologists in each state immediately in advance of the appearance of a brood, giving them the records of towns in which that brood has appeared and asking them to survey their state as thoroughly as possible for the coming emergence. Since this work was started, we have added very materially to the known distribution of several of the broods. This, however, is probably the simplest phase of the problem.

Some unanswered questions.—When an appearance of the periodical cicada is at hand, the first thing observed is the newly emerged nymph, yet no one has ever seen a nymph coming out of the ground. Some writers have stated that the nymphs open their burrows several days before emerging; others, that on the evening before the first wave of emergence not a hole was visible. It has also been stated that a month prior to emergence the cicada nymphs move to within a half-inch of the surface, and Snodgrass very definitely proved, by making casts, that they construct an open chamber 1 to 6 inches long. It is interesting to know how long they stay there. Are they awaiting a signal to come out?

Now we will suppose that they have emerged. It is stated that they crawl toward and up trees; but do they crawl toward a tree consciously, or do they simply crawl in any direction until they strike some obstacle? Are they attracted by the shadow of the object upon which they climb? This hardly seems possible, as they emerge in the night. Much could be done this coming May to throw light on the response of these nymphs

to such stimulae as might lead them to a desirable place for the final transformation.

When up the tree, so it has been stated, they very carefully fasten themselves to the leaf, twig or bark in order that the pupal case may not lose its hold while the adult is emerging; and we are led to believe that should they fall to the ground they would not be able to emerge, but is this so? Could they not emerge just as well on the ground?

Shortly after emerging, the males start to sing. Why? This song must be a sex response, since the sound organs are confined to the males. But how does it function? Does it function as a means of bringing the sexes together? We can hardly imagine that a sound so extremely specific, so peculiar to this insect, has merely an aesthetic purpose. Granting that this modification of the structure of the insect to produce this sound and the peculiarity of the sound are necessary for the continuation of the species, is there not an intriguing field for investigation on the part of the entomologist, not only of this insect but of all those insects which produce peculiar and characteristic songs? Why would it not be possible to mask these sounds or to dampen them to such an extent that the receiver could no longer distinguish them, and thus put a definite obstacle in the way of the sexes meeting and consequently in the way of reproduction. We can give play to our imaginations and actually *hear* the entomologists controlling insect pests! We can see in the agricultural fields the tone-modulating machine in the place of the spray machine and the duster! This is very fanciful, but the scientific entomologist should thoroughly understand the response of insects to the calls emitted by their own kind, and it is not unreasonable to believe that he might use this knowledge to his own advantage. It is known that insects are capable of making sounds in the supertonic range, that is, beyond the range of audibility. The limit of normal human hearing is between 15,000 and 20,000 vibrations per second. It is also known that sounds can be masked by lower-pitched sounds of but slightly higher intensity, and this masking sound can be constantly reduced as we approach the fundamental frequency. This song is also very inadequately described. Some good phonograph, phonoscope, or oscillograph records of the song of the 13-year and 17-year races and of the small variety *cassinii*, which is said to differ very materially from that of the typical *septendecim*, would do much to clear up our knowledge of the song.

Other senses of insects.—Now that we are using our imagination, why is it not feasible for us to attack insects through their sense of smell? We know positively that many insects discover their mates by this sense. Could not a synthetic odor be produced and sprayed in a concentrated form in a very limited part of the infested area, and so concentrate the males as to render most of the females infertile?

The sense of touch also can be turned to advantage. This has been demonstrated in the fact that termites will not infest buildings in which there is a vibration maintained by moving machinery. This, of course, may be a simple disturbance. On the other hand, it may be a masking of the communicative vibrations of these insects.

Mating starts a few days after emergence. It has been stated that

cassinii will not mate with *septendecim*. This needs further proof. It would be interesting to observe if the 17-year and 13-year races will mate and produce fertile eggs. A little cooperation on the part of entomologists in the gulf region and those in some of the northern states would probably throw light on this subject; and, inasmuch as the insect occurs over the entire eastern part of the United States, it might be possible to obtain permission to ship living specimens from place to place.

To go back to the emergence: it has been very definitely stated that this is not regulated by climatic factors. This is possibly true, but there is but little scientific evidence to substantiate the statement. If a number of graduate students located, for instance, in the middle Atlantic states, in the east central states, in the gulf region, and in the south Atlantic states, could be assigned a project on this insect for this coming spring, they might throw much light on this moot question.

A very simple apparatus, such as a recording hygrothermograph, placed in a small shelter on the ground, would give valuable data on emergence. This could be elaborated by making the shelter a closed cage or inverted box with the temperature held constant by a thermostat and a small electric heating unit. Further to elaborate the investigation, several such cages could be used at varying temperatures and humidities. Later in the season, this apparatus could be used to throw light on the effect of varying conditions on the hatching of eggs. In fact, these eggs suggest a number of interesting problems.

It has been said that the eggs actually grow by absorption of plant juices, and that if the twigs are removed from the trees and allowed to die, the eggs will not hatch. As far as we know, however, no observations have been made of these eggs under controlled conditions. Death might not really be a matter of starvation of the egg, but of desiccation or crushing. At the same time that these phenomena were being observed, light could be thrown on the length of the egg period under different controlled conditions.

It is well known that the periodical cicada, under certain conditions, constructs very peculiar turrets, from 1 to 8 inches high. These are supposed to be in response to moisture, and to be built in situations in which the nymphs would otherwise be in wet soil immediately before emerging. On the other hand, there is a definite record of the building of these turrets in a dry shed, and the building may be a response to light. In the temperature-controlled boxes, this question also could probably be answered. The soil under some of the boxes could be kept saturated with water during April and May, and the soil under other boxes could be kept dry. Field observations of soil conditions where the turrets are naturally built are also desirable. Just how these turrets are constructed is also unknown. Does the nymph come out on the surface and build a turret and then close it over at the top, or does he work up from within, keeping himself always within his closed turret? Does this insect have a soil preference or a vegetation preference? There are some data to indicate that it has both, but careful descriptions of the plant complex and the soil types over a wide area alone can give us a scientific basis for any such statement.

Hatching.—We have taken the cicada from the ground, brought him to the tree, had the adult emerge and sing its song, mate, and lay its eggs. Now these eggs must hatch. It is known that the eggs nearest the exit to the egg pocket hatch first, yet undoubtedly these were the last eggs to be laid. Therefore, the incubation period is in inverse ratio to the order of oviposition. It is easy to understand the economy of such an arrangement. If the egg at the bottom of the chamber hatched first, the nymph would be very much impeded by its unhatched brethren blocking its way out, but if time of maturity is not the final stimulus to hatching, what is? Is it that the eggs nearest the entrance are more exposed to warmth, moisture, drying, or some other factor that makes them hatch first, or is it that they are under lower pressure from the surrounding wood and that as the first eggs hatch, they release the pressure on the next eggs and thus the hatching becomes an indirect response to pressure. This is a problem to tax the ingenuity of the experimental zoologist.

Having hatched, the young larvae are said to jump or fall to the ground, where they burrow in or crawl into cracks, and finally reach a rootlet upon which to feed. Do these young nymphs burrow into the ground, or do they simply use such natural openings as are available? It is also said that having once fixed themselves to a rootlet, they remain there, only moving when forced to do so by the death of the root, and that they occupy the same position until they make their final movement to the surface just before emerging. Inasmuch as the more mature nymphs have been found in the ground at a depth of at least 2 feet, with doubtful records up to 5 and 8 feet, it hardly seems possible that this tiny, recently-emerged nymph could work its way to such depths without starving to death enroute. Some interesting observations could be made during the months of August, September, and October of 1936 to find where the nymphs are in the ground. Similar observations made the following few years should prove very definitely whether these insects move about in the soil. I am very much inclined to believe that they do. Observations could even be made in winter by locating the nymphs, from January to May.

Natural enemies.—The males having sung their song, and the females having laid their eggs, die, but what occasions their death? Do they all die of old age? A very interesting fungous disease has been observed on some of the adults, but is this a disease or is it merely a saprophytic fungus living on insects that have been wounded? Little is known about this disease, and an investigation in cooperation with a mycologist or pathologist would be well worth the trouble. If it is a specific disease of the periodical cicada—and it seems to be—its resting stage must carry over either within the body of the cicada itself or in the soil. We have found no records of the discovery of fungous spores in the nymphs or in the soil. We have found no records of the inoculation of apparently healthy individuals with the spores. In fact, this fungus is still among the *fungi imperfecti*.

Undoubtedly a number of these insects are destroyed by natural enemies. An asilid or bombyliid larva, a cecidomyiid larva, and a thysanopteron in both the larval and adult stages are known to attack the

eggs, and ants are said to prey on both the eggs and young larvae. The genera and species of these predators are unknown. There is a chalcid, *Latromerus cicadae* Howard, that parasitizes the eggs. There are several undescribed tachinids that have been observed to attack the adults. The wasp *Sphecius speciosus* Drury, that uses the adult as food for its young, is well known. Eleven genera of Acarina have been found associated with the eggs, but we are still ignorant of the rôle they play in the cicada's life. Birds and mammals feed on the emerged nymphs and on the adults. Detailed observations as to the extent to which this feeding takes place are much needed.

We have followed this insect from egg to egg in displaying our ignorance. Cannot the year 1936, when the great northern Brood X and the lesser southern Brood XXII appear, be used to dispel at least a part of this darkness?—6-27-36.

OCCURRENCE AND SEQUENCE OF MOSQUITOES IN SOUTHEASTERN ARKANSAS IN 1935

W. R. Horsfall, *District A. and M. College, Monticello, Ark.*

Mosquitoes are among the most important insects of economic importance in the coastal plain region of Arkansas. It is for this reason that it has seemed advisable to make a study of the species that inhabit the region in order that the larval habitats, the adult habitats, and the seasonal sequence may be used as a later basis for control.

This report is based upon data which were obtained during the year 1935. The Agricultural and Mechanical College furnished a student assistant[1] for the early spring and fall, and the summer work was made possible as a result of a grant made by the Committee on Grants-in-Aid of the National Research Council. To these organizations I am grateful for financial assistance. Dr. Robert Matheson of Cornell University gave valuable assistance in determining many of the species.

Geography of the area.—The region of Arkansas covered in this survey of the species was limited to the area between the Saline river east to the Mississippi and from Louisiana north to the southern part of the rice district, which is located in the east-central part of the state. There are many low, broad bottom lands along the rivers, bayous and smaller streams. Between the rivers are sandy and gravelly clay hills having among them many short streams that contain flowing water only during and shortly after rains. The rivers and bayous have water in them continuously and often overflow during the winter and spring, leaving many pools and sloughs.

The rice district in the east-central part of the state, between the Arkansas and White rivers, is an area of flat clay land that is artificially flooded for the growing of rice. The alternate flooding and partial drying

[1] Mr. A. C. Trimble did much of the rearing and collecting.

of great acreages present some unique problems in connection with mosquitoes.

The winters of southeastern Arkansas are periods of much rainfall interspersed with several periods of subfreezing temperatures. During the late spring, namely the latter part of May and early June, the periods between rains become longer, and the rains, which are often hard, are of short duration. As a result there is an alternate flooding and drying of the pools and streams. The summer is a period of high temperature and low rainfall with long intervals between the short beating rains. Most of the pools dry completely within a week or less after each of the rains. In October or November the rainy season begins, the water table rises, and the pools and streams become filled with water.

Methods of procedure.—In order to study satisfactorily the species of mosquitoes which inhabit any area, it is essential to have both males and females and, wherever possible, the last larval exuvium of each species. Many of the species are difficult to determine by means of the female alone unless one knows what species occur in the locality from which the specimen was collected. On the other hand, the hypopygia of the males and the last larval exuviae provide good characters for separation. Therefore it is necessary to collect the immature stages from many typical habitats and to rear the imagoes.

All of the specimens which were reared during the year were kept in small glass aquaria which contained water and food material from the native or a similar habitat. An attempt was made to similate the natural environment in all particulars that were feasible at the time. When the field work began, the plan was to make collections and field observations at all of the places of collection once a week, but such a plan was found to be impractical. Instead collections were made at such intervals as the season, the rainfall, the species and the available time permitted.

The larvae and pupae in the pools and streams were collected with a fine-meshed tea strainer and transferred to 8-ounce collecting bottles with dropping pipettes for removal to the laboratory. In order to collect from holes in stumps a modified suction flask was used. The larvae were sucked into the flask through a rubber tube long enough to reach to the water in the hole. Otherwise the larvae were treated in the same fashion as the others. In the laboratory each collection was divided into small lots and put into small glass bottles for rearing. Single-larva cultures were made in most instances so that the last larval exuvium, the pupal exuvium and the adult could be obtained for representatives of the several species. Moss, dry grass, pond weed and dried cow manure were variously used as sources of food for the larvae of those species which were not primarily cannibals. Those species whose larvae fed on other mosquito larvae were fed from stock or were allowed to feed on one another. Fairly good results were obtained by following this technique with larvae in the last instar, but there was a high mortality for those of earlier instars.

Conditions in the laboratory were somewhat similar to those in the field regarding temperature, water and number of larvae per unit of surface area. However, a close check was kept on the field conditions in

order to see whether the emergence was comparable. For the range of accuracy desired the technique was satisfactory.

Results.—Twenty-three species of mosquitoes were collected during the year. Of this number eight are considered of general economic importance because of their numbers, their general distribution, and in some cases because of their disease relations. Five are recognized as of

Table 1.—A list of the species of mosquitoes collected in 1935.

Species	Larval Habitat	Adult Habitat	Beginning of Emergence	Height of Emergence	End of Emergence
		General Economic Importance			
Aedes canadensis (Theobald)	Woods, pools, streams	Woods	Feb.	Late March	Early May
Aedes vexans (Meigen)	Woods, open pools, ruts	Grass, houses	April	Late April	Late June
Culex quinquefasciatus Say	Pools, artificial containers	Grass, houses	May	July, Aug., Sept.	End of Nov.
Anopheles quadrimaculatus Say	Woods, open pools near houses	Grass, houses	June	July, Aug., Sept.	?
Anopheles punctipennis (Say)	Woods, open pools	Woods, grass, houses	April	May–Nov.	?
Culex territans Walker	Woods, pools	Woods, houses	April	Early May	Late June
Psorophora varipes (Coquillett)	Overflow pools	Dense woods	May	Late May, early July	Late July
Psorophora columbiae (Dyar & Knab)	Open pools, houses	Woods, grass	June	After rains, June–Oct.	Nov.
		Local Economic Importance			
Aedes thibaulti (Dyar & Knab)	Tree holes	Dense woods	March	Late March	Late March
Aedes triseriatus (Say)	Tree holes	Dense woods	March	April	Dec.
Psorophora posticata (Wiedeman)	Woods, pools	Woods	April	April	Early June
Psorophora ciliata (Fabricius)	Woods, open pools	Grass, woods	May	June, Sept.	Late Sept.
Culex salinarius (Coquillett)	Woods, pools	Woods?	April	?	Early May
		Little or No Economic Importance			
Orthopodomyia signifer (Coquillett)	Tree holes	Woods	March	Aug.–Sept.	Dec.?
Culex inhibitator Dyar & Knab	Grassy pools	?	June	June	Early July
Culex peccator Dyar & Knab	Pools in dense woods	?	June?	June	Early June
Anopheles barberi Coquillett	Tree holes	?	June	July–Nov.	Dec.?
Theobaldia inornata (Williston)	Pools in slight woods	Woods	March	March	1st brood Apr. Fall brood?
Psorophora howardii Coquillett	Woods, pools	?	June	Late June	July?
Culex apicalis Adams	Woods, open pools, streams	Woods	May	June	Dec.?
Megarhinus septentrionalis Dyar & Knab	Tree holes	Woods	March	July–Sept.?	Nov.?
Aedes sp.	Woods, pools	?	June	?	?
Psorophora sp.	Open pools	?	?	?	?

local importance because in some localities at certain seasons of the year they cause some annoyance. Ten are listed as of little or no economic importance. They either rarely occur in sufficient numbers to be classified as important or they are not known to suck human blood. For that reason they are not discussed in this short paper. The species are grouped below in a tabular form according to their relative economic importance.

In March and April *Aedes canadensis*, *A. triseriatus* and *Psorophora posticata* are very annoying in the woods. *A. canadensis* females are

generally distributed in the woods while the other two species augment the annoyance to man in the stream and river bottoms. As the spring floods begin to recede in the valleys of the principal streams and rivers, *Psorophora varipes* adults occur in enormous swarms at all times in the vicinity of their breeding places. At such times it is very painful to walk through the woods of the bottom lands unprotected. The brood which developed in the flood waters from the Arkansas and White rivers in July were so annoying that it became necessary to use gloves and veils to collect in the vicinity of the breeding places.

In the upland open areas and fringes of woods during late April and May, *Ades vexans* and *Culex territans* are very annoying. They enter houses in thickly populated areas only infrequently, but in rural communities where houses are in or near woods these species enter them readily.

Culex quinquefasciatus, *Anopheles quadrimaculatus* and *Anopheles punctipennis* are the species that commonly invade houses. *C. quinquefasciatus* is by all odds the most important numerically in the upland regions. *A. quadrimaculatus* is a close second in the houses of the rural people in the river valleys. The adults of these species are so abundant and persistent during the summer and fall that some are found in almost all houses even though they be well screened. The first two species breed close to human habitation in general while the last one does not seem to be so limited.

The rice district in the northern part of the region included in this paper presents a peculiar variation. In the first place *Psorophora columbiae* is the dominant species coming from the flooded rice fields in great swarms. All day in the bright sun or in the woods they are annoying from June to October. At night they are a veritable scourge.

Anopheles species and *Culex* species were uncommon to rare in the heart of the rice district but toward the river bottoms to the south and west where less rice is grown *Anopheles* and *Culex* become dominant.

Summary.—While the data presented in this paper are by no means conclusive, they indicate the sequence and distribution of the more common species of mosquitoes in the coastal plain of Arkansas. Twenty-three species are discussed.—1-13-36.

FOOD PLANTS OF SOME ARIZONA GRASSHOPPERS

E. D. BALL, *University of Arizona, Tucson*

When one says "grasshoppers" the immediate reaction is of something bad because the few bad ones have had all the publicity and attention.

The writer's previous study of the grasshoppers of Colorado, and a recent one of those of Arizona, indicate that out of about 130 species of true grasshoppers occurring in each state only five or six should be classed as injurious to crops, and scarcely more than a dozen more should be listed as of serious injury to the grasses of the range. This leaves well over 100 either beneficial or of little importance one way or the other.

The grasshoppers injurious to cultivated crops are all long winged and most of them are more or less migratory. The grasshoppers injurious to the range are on the other hand nearly all short-winged, and therefore very limited in movement. Many of the short-winged range forms have a peculiar method of protecting the females. The females are large and clumsy, and obscurely colored to blend with their normal surroundings, while the males are small, active and brightly marked. As one approaches, the males leap into the air, make a flip or two, alight and spring up again, thus distracting the eye from the obscure female hiding in the grass, and even if the female is forced to jump she alights and immediately hides while a dozen males spring up and distract the eye. This is apparently a very clever protective adaptation.

Food relations.—Under the arid conditions of the southwest shrubs are usually widely spaced and even the grasses do not ordinarily form an unbroken cover. Even more important than this is the fact that one can find large areas in which one shrub or grass practically dominates, while with a slight change in elevation, slope or soil type another species will take its place. Thus within a few miles one may often find a dozen pure stands of as many different plants. With elevations from sea level or below up to 12,000 feet, and annual precipitations from 4 inches or less to abundant moisture for forests and meadows, every opportunity is offered for a diversity in both plants and animals rarely equalled. The writer in the few years' study in the biology of the range grasshopper has worked out a large number of very interesting and instructive food relations, a few of which are cited to illustrate the diversity in adaptation and at the same time the fixity of these food habits.

The monkey grasshopper, *Eumorsea balli* Hebd., which feeds on the Mexican nut pine, *Pinus cembroides*, is strikingly mottled to resemble the small twigs from which the needles have recently fallen. It is entirely wingless and has extremely long legs, with an especially long claw on one side and a short one on the other, which no doubt enables it to swing from the needles or small twigs as it jumps from one limb to another or even from tree to tree.

The Arizona race of the chaparral grasshopper, *Morsea californica dumicola* Rehn & Hebd., a California species, is apparently confined to the mountain mahogany, *Cereocarpus ledifolius*, an abundant shrub in the chaparral belt. This species is also wingless, but instead of jumping from branch to branch when disturbed, it jumps to the ground beneath the shrub. Here its resemblance to the fragments of twigs and branches scattered about is so complete that it is very difficult to locate.

The toothpick grasshopper, *Achurum sumichrasti* Saus., feeds on the broom rape, *Andropogon barbinodis*. The nymphs feed on the basal leaves in fall and spring, while the adults appear with the new stalks, which they resemble in their reddish and green striping. When this grasshopper flies it zooms up at the end and alights upright on the stalk, immediately dodging behind it and disappearing from view.

The creosote grasshopper, *Bootettix punctatus* Sc., is found only on the creosote bush, *Larrea tridentata glutinosa*, of the hot deserts. Its color scheme of greens, brown and white is almost identical with that of the

katydid on the same plant, although the pattern and arrangement are quite different. In both cases they blend so well with its brown wood, shining green leaves and broken sunlight as to be invisible.

The Texas longhorn grasshopper, *Pedioscirtetes maculipennis* Sc., is a rare and beautifully marked grasshopper with long antennae, and is strictly confined to the little heatherlike mat *Coldenia canescens*, to which its color and pattern so beautifully adapt it.

The clicker, *Liguortettix coquilletti kunzei* Caud., is another inhabitant of the hot deserts whose soft clicking noises can be heard in every direction, but to capture one is a difficult matter. Their soft brown and buff coloration blends with the lights and shades of the creosote stems and they dodge with agility from stem to stem. They have a remarkably developed stridulating area along the costal margin of their elytra.

The crested grasshopper, *Tropidolosus formosus* Say, is one of the rarest and most striking of our Arizona species, and feeds exclusively on a mallow, *Malvastrum coccineum*. This is a very small mallow, only a few inches high, but a pair of these big grasshoppers will conceal themselves under the margin of this plant, where their pink, green and white crest blends remarkably. If one walks onto a pair, the male will spring up, spread the orange-red wings, and glide away for a rod or two. The female rarely moves from the plant, her wings being too short to fly. She apparently depends upon the striking orange wings of the male to distract attention from her hiding place.

The lichen grasshopper, *Scirtetica ritensis* Rehn, was discovered by Professor A. A. Nichol and Dr. C. T. Vorhies on a vast rock slide high on a north slope of the Santa Rita mountains. These rocks were covered with a mottled green and black lichen interspersed with orange-red ones. The writer visited the area and observed that they were always on the green lichen but when disturbed would spread their orange wings and make a rapid flight over the orange and green areas, finally folding their wings in midair with a twist that would send them to one side of the line of flight to light again on a green and black cluster. Later they were found on an almost perpendicular north face of a canyon, much lower but with the same lichen growths.

The alkali grasshopper, *Anconia integra* Sc., is a large, spotted and green species with smoky under wings, abundant in and around alkali areas in the hot creosote bush deserts. Its primary food plants seem to be the desert salt bush, *Atriplex polycarpa*. The nymphs are practically all on this bush and only abundant when this bush borders an alkaline area on which sea blite, *Dondia torryana*, normally grows. The adults may be found on either shrub. The small light-colored males often occur on the bare sands.

The wash grasshopper, *Heliastus benjamini* Caud., is a dull-brown hopper with striking red under wings, abundant in all the rocky washes in the desert and lower mountain areas. The nymphs, like those of most of this group, never appear to eat anything but they have been found so abundant in broad rocky washes where the only green thing was the green algae in the pools or under the margin of the rocks that the writer is convinced that they either eat it directly or else secondary fungi that

hasten its decay. The grouse locusts all appear to live on the green slime and the writer is beginning to wonder if a lot of the Oedipodinae do not live on saphrophytic fungi growing on decaying vegetation.

The malapais lubber, *Tytthotyle maculata* Brun., is found in abundance on the hottest, barest parts of the black lava flows in western Arizona. The adult is long winged and mottled brown, while the nymphs are squat, toadlike and black. They hide under the shade of the biggest rocks during the heat of the day when this black sand may go to 160° F or more and only step out in the evening or morning. The only food plant of any importance in many of the areas where they were thickest was the horned toad buckwheat, *Chorizanthe rigida*, which forms a miniature Chinese pagoda, each succeeding story more spiny than its predecessor.

The colonel, *Taeniopoda eques* Burm., is a stately grasshopper whose striking black, yellow and red are supposed to be warning colors of a distasteful species—as in the Mexican army grasshopper—but this has not been tested. This ordinarily rare species was extremely abundant in 1935. Two hundred were collected in two hours. Four to eight feeding on the crushed remains of a comrade on the road was a common sight. This hopper appears to requires two food plants. One of these is the mesquite tree and the other usually a Composite, either the burrow weed, *Aplopappus* sp., or the snakeweed *Gutierrezia* sp. Where neither of these is present, as in broad, rich bottoms, then the gray thorn, *Zizyphus lycioides*, is utilized. The nymphs alternate between the plants but as the females develop eggs they spend more time on the weeds, probably because they furnish the rubber for the covering of the egg pod. Wherever the females are, the males follow, so that in the later and heaviest feeding stages they are feeding on the two worst weeds of the range.

The cattail grasshopper, *Leptysma marginicollis* Serv., was found in nymph and adult stages feeding on pure stands of cattails in several places. This species, like *Achurum*, zooms up right at the end of the jump or flight and, alighting upright on the stem, it quickly dodges around to disappear.

The gray bird-locust, *Schistocerca vaga* Sc., is a long, slender but powerful flying machine and the closest Arizona relative of the plague locust of the Bible. Adults of this species are not ordinarily abundant and the nymphs are solitary and rarely seen in ordinary years. In 1935 they increased in numbers until five or eight nymphs could be taken in one sweep of the net, and on a humid evening in October there was a flight of adults into the cities of Phoenix and Tucson that attracted much attention.

The food plant of the nymphs of this species is the perennial ragweed, *Ambrosia psilostachya*, which is abundant all over the range country. A few were found on *Mimosa* sp., usually where the ragweed had been eaten up. The adults live over winter and the ragweed freezes down and does not appear until late in the spring. The adults go to the trees for winter for shelter and remain there until late in the spring.

The marbled bird-locust, *Schistocerca lineata* Sc., is a big pale, white-lined species with ivory spots on the pronotum, and is found along a few miles of the Mexican border in Arizona. The nymphs were found in

abundance feeding on the crowns of the side-oat grama. The adults flew to the yucca and oaks for roosting purposes but came back to the grass to feed.

The salt-bush grasshopper, *Aeoloplus chenopodii* Br., is a fat green variety, nymphs and adults of which feed on a pure stand of salt bush, *Atriplex argentia*.

The athletic grasshopper, *Aeoloplus tenuipennis* Sc., is a pretty grasshopper with big biceps which occurs everywhere in the southwest on *Atriplex canescens* and less commonly on *A. polycarpa* and *A. lentiformis*.

The goldenrod grasshopper, *Hesperotettix curtipennis* Sc., was found feeding exclusively on goldenrod, *Solidago sparsiflora*, in the yellow pine belt at 7000 feet and above.

The green-streak grasshopper, *Hesperotettix viridis* Th., feeds primarily on snakeweed, *Gutierrezia sarothrae*, secondly on burrow weed, *Aplopappus* sp., and thirdly on rabbit brush, *Chyrysothamnus* sp., three of the worst weeds of the range. In cycles of abundance it often strips every leaf from thousands of acres of snakeweed, weakening and finally killing a large percentage of the plants.

The leopard grasshopper, *Poecilotettix pantherinus* Wk., feeds exclusively on the small perennial sunflower of the mountain slopes, *Helianthus* sp. This sunflower is a strong competitor of the grasses in certain areas and when numerous this grasshopper holds it in check.

The red-lined grasshopper, *Poecilotettix sanguineus* Sc., occurs abundantly on the desert broom, *Baccharis wrighti*, which grows in low clumps in the grasslands. These grasshoppers scatter as one approaches but come back soon after. In cycles of abundance they often eat every leaf and then chew the bark from the tender twigs before abandoning the bush.

The gloriosa grasshopper, *Perixerus gloriosus* Hebd., a beautiful green and scarlet form which Dr. Morgan Hebard has just described, is known only from a very small mountain area on the Mexican border, where it replaces the previous species on the desert broom. It has the same habit of leaving the plant if approached. It appears late in the fall, while the red-lined grasshopper is an early summer form.

The variegated or "Mexican army" grasshopper, *Dactylotum variegatum* Sc., is another bright "warning-colored" species that certainly delights in getting out on a flat rock or in an open road to take a siesta. The desert broom is apparently the food plant of this species also, although its wanders away at times, especially at the mating season. The young nymphs are often found in a cluster at the base of this plant, but if once scattered they wander to other plants of this species and become widely distributed.

The brownie grasshopper, *Bradynotes kaibab* Hebd., is a fat overstuffed and almost wingless little hopper that feeds on a matlike everlasting, *Eriogonum* sp., in the open meadows of the Kaibab.

Red whiskers, *Melanoplus desultorius* Rehn, is one of the few short-winged forms of this genus on the desert grasslands. This is probably the most beneficial hopper in the state, as it feeds almost exclusively on the perennial ragweed, *Ambrosia psilostachya*. This is the outstanding hay-

fever plant, and one which no animal will touch. On overgrazed ranges it becomes a serious menace. Red whiskers was exceptionally abundant in 1935 and in many areas the ragweed was eaten up early in the summer after which the insect had to forage the best it could.

The flabellate grasshopper, *Melanoplus occidentalis* Th., and the crested grasshopper feed on the same mallow, *Malvastrum coccinea*. This small species is widely distributed to the north and east, which is the home of these mallows. The adults fly readily but with an ordinarily careful approach, the nymphs may be found on the plants.

The arrow-weed grasshopper, *Melanoplus herbaceus* Br., is strictly confined in food habit to one plant, *Pluchea sericea*, and thus limited in distribution to stream banks.

Most Arizona species beneficial.—In summarizing, one sees that many grasshoppers are strikingly beneficial in that they help to check the weeds that would otherwise overrun the overgrazed ranges. And parenthetically, one may add that all ranges *are* overgrazed and that it is high time we knew more about the possibilities and opportunities of overgrazing the weeds that are taking or have taken the place of the grasses.

We find that the very worst weeds of the western ranges have their grasshopper enemies. The burrow weed has two, the snakeweed two, the ragweed two and the mallow two. These are plants that no form of livestock will graze and which therefore multiply when the grass is reduced. The creosote bush has two, the *Atriplexes* three, the sunflower, the goldenrod and the arrow weed each one. These are shrubs that have no grazing value and take the place of others that might have. The desert broom with its three grasshopper enemies is a fair forage plant but takes the place of grasses which are better. Some of the records like the lichen and the algae are only of scientific interest but one must remember that the grouse locusts all feed on algae, that the colored-winged grasshoppers with few exceptions are merely ornamental, that the katydids are amusing, the cave crickets curiosities, that the eight mantids we have feed on grasshoppers, that the snowy tree crickets feed on aphids, that the *Myrmechophilas* act as valets to the ants, and the small mole crickets, *Tridactylus*, make their tunnels in the river sands.

We find in fact that the great majority of the 250 species of Arizona orthoptera are either interesting, amusing or beneficial. May their tribes increase! The seriously injurious species are few in number and nearly all confined to two groups of omnivorous feeders.—1-4-36.

STUDY OF CHINCH BUG POPULATIONS IN OHIO

F. B. Whittington, *Ohio State University, Columbus*, and L. L. Huber, *Ohio Agricultural Experiment Station, Wooster*

In April, May and December of 1935, chinch bug population studies were made in several of the principal wheat-growing counties in Ohio. The purpose of these studies was to secure data concerning relative

abundance of chinch bugs, in order to facilitate control recommendations.

To secure comparable results from all localities it seemed advisable to make examinations of a hibernating medium common throughout the part of the state to be surveyed. Preliminary examination of various types of media indicated that volunteer timothy clumps ranked high in bug populations. In table 1 the populations of one-fifth square-foot samples of timothy and June grass taken in the same localities are compared.

From a survey standpoint, it appeared evident that if volunteer timothy occurred in sufficient abundance in all counties, it would provide a satisfactory sampling medium. To determine the relative abundance of volunteer timothy for the counties the number of clumps in five one-rod areas was counted; each area was chosen at random along the roadside and was identical with areas from which samples were taken for chinch bug analysis. The relative abundance of timothy is shown in table 2, next page.

In determining the abundance of chinch bugs, seven to 15 square feet of volunteer timothy were selected at random[1] in each county. Each

Table 1.—Relative abundance of chinch bugs in one-fifth square-foot samples of volunteer timothy and June grass sod, Ohio, 1935.

Volunteer timothy	7	98	84	21	54	4	192
June grass sod	2	4	1	5	4	1	4

square-foot area was collected at random in one-fifth or one-eighth square-foot units, placed in a paper bag, and taken to a warm room for examination. In the first counties surveyed each square foot consisted of five sample units. Samples were secured from 20 counties in the spring and eight in December. In addition, two counties were surveyed in June.

Analysis of the data presented in table 2 indicated a significant variation in the chinch bug populations of the 20 counties surveyed. Such a variation was not unexpected. However, the survey showed in what counties, other factors being equal, most serious damage to corn might be anticipated and where control measures would be most needed.

The relative number of bugs per county was determined by multiplying the product of the mean number of bugs per square foot and the mean number of timothy clumps per rod of roadside by the number of square miles per county. The result of this calculation is also shown in table 2. It was quite apparent that the population present in a number of north-central Ohio counties was sufficient to cause considerable damage. Had it been necessary to distribute creosote, these data would have shown roughly the amount of creosote required in the various counties.

General observations combined with surveys in Wayne and Marion counties during the middle of June pointed to the collapse of the outbreak that was threatened in April and May. A survey of several counties in the first two weeks of December showed still more clearly the tremendous reduction in population. The average population of eight counties showed approximately one-fourth as many bugs in hibernation in December as in April and May.—7-8-36.

[1] Samples were not taken entirely at random in Clark county.

Table 2.—Chinch bug populations in Ohio counties surveyed in the spring and winter of 1935.

Counties	Means per Sample Unit															Mean Timothy Clumps per Rod	Relative Population per County
	April and May Survey																
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*		
Hancock	8	14	14	23	9	1	20	17	4	11	1	38				11	38
Wayne	0	1	4	15	5	16	7	0	0	8	1	9	0	2		12	36
Licking	2	1	3	1	19	1	3	14								15	27
Richland	38	1	0	1	1	6	54	3	2	2						11	30
Seneca	3	4	12	4	2	4	73	1*	1*	5*	9*	1*	2*			10	27
Clark	0	12	11	2	6	1	15	4								11	21
Wood*	2	37	13	1	2	1	0	2	2	2						9	26
Wyandot*	3	2	16	14	14	11	23	10	1							8	16
Medina*	4	19	2	3	13	9	15									6	19
Stark*	0	0	0	2	12	13	2	2	16	3						6	14
Marion*	0	1	1	1	4	2	6	4	1	1	2	1	9	13	2	7	7
Putnam*	1	1	2	0	0	2	0	0	6	1	1	2	0	0	0	16	7
Erie*	2	2	4	1	2	2	1	2								13	5
Van Wert*	0	1	5	5	0	0	0	1	0	1	6	6	2	0		8	5
Henry*	1	1	3	4	2	5	1	6								5	5
Sandusky*	1	1	10	1	2	1	0	1								6	4
Defiance*	1	0	1	1	0	1	2	0	0	8	0	1	0	0	0	13	4
Williams*	1	0	5	0	1	0	0	0	1	1	1	5	1			9	4
Madison	3	0	1	1	1	2	3									6	2
Champaign	2	3	0	2	1	2	1									8	2

	June Survey	*December Survey*															
	Relative Population per County	Means per Sample Unit															Relative Population per County
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	
Hancock		1	0	0	4	0	1	0	0	2	0	1	0				2
Wayne	17	0	1	4	2	0	4	1	0	1	0	0	0	0			3
Richland		1	4	1	27	6	1	3	10	8	6						4
Seneca		1	1	0	0	4	0	3	0	5	2	0	0	0			4
Wyandot		6	56	1	6	5	3	1	2	1							15
Medina		1	1	10	3	5	33	10									10
Stark		2	2	12	11	2	1	0	0	1	1						6
Marion	3	2	3	1	0	0	4	0	0	1	0	0	2	0	0	0	1

* Averages of eight samples per square foot.

RELATIVE RESISTANCE OF SELECTED STRAINS OF CORN TO EUROPEAN CORN BORER

G. A. Ficht, *Purdue University Agricultural Experiment Station, Lafayette, Ind.*

The variability of European corn borer populations occurring in different strains or varieties of corn has been studied over a period of years with the object of determining the presence of resistance and of selecting a strain or strains showing a relatively high degree of resistance which might be of use in future corn borer work. In addition, some attempts have been made to measure the character or characters existing in the plant which might contribute to resistance. This paper will show that certain strains which have been tested are relatively resistant as compared to some other strains which have been included in the experiments.

The variability of corn strains as to the number of eggs they receive, their comparative rates of borer survival and their final borer populations, have been demonstrated by several workers. Patch (*3*) has stated that greater corn borer populations in the earliest plantings of both field and sweet corn are indicated as due to the preference of the corn borer moth for the tallest corn. Neiswander and Huber (*2*) state that corn borer population is fundamentally the result of either the number of eggs deposited, or the rate of larval establishment, or both, and that height and silking date are closely correlated with oviposition and establishment. They have shown also that a significant difference exists in the rate of survival on a given strain or variety of corn when in different stages of development during the establishment period of the borer, the later planted and less mature corn having a lower rate of survival than the earlier and more mature corn.

Since the variability of corn strains to oviposition is largely relative to their height during the period of oviposition in the plantings being studied, the less vigorous, slower growing and shorter strains appear from their populations to have a degree of resistance which might not occur in the absence of taller and more rapidly growing strains. For this reason the percentage of borers which establish themselves within the plants and become full grown is probably the more important measurement indicating resistance. Hence, the survival rate, which expresses the percentage of full-grown larvae resulting from an estimated number of eggs deposited naturally on a given number of plants, is the factor chiefly considered in the discussion of the strains tested.

The corns used were chiefly hybrids[1] although a few inbreds, open-pollinated varieties and top crosses were used. Selections were made to provide a wide range of plant characters which might have a bearing on resistance.

The procedure followed during all years of this study has consisted of the routine counting of egg masses naturally laid upon the plants and

[1] The writer wishes to acknowledge the assistance provided by J. F. Trost, R. R. St. John and J. R. Holbert of the U. S. Department of Agriculture, Bureau of Plant Industry, in selecting the strains and providing the seed of all but the open-pollinated varieties.

the determination of the average number of eggs per mass. This has provided an estimate of the number of eggs present on a given variety of corn. Dissection of the plants at the time the borers became full grown has provided the data on larval survival.

The work of 1934 and 1935 was conducted at Auburn, Ind.,[2] and the work of the two previous years at Monroe, Mich.

Experiments of 1932.—The experiments of this season included plantings of two inbred lines, an open-pollinated variety and 6 hybrid strains arranged in a randomized block comprised of 4 replications of each strain.

As would be expected from its relative earliness as compared to the other strains used, Clement's White Cap, a midseason variety, showed a significant lack of resistance as expressed by its rate of corn borer survival.

Table 1.—Eggs depositions, larval populations and survival rates on eight strains of corn studied in 1932.

Variety or Strain	No. Eggs per 100 Plants	No. Borers per 100 Plants	Per Cent Survival
Clement's White Cap	3406	415	12.97
46×C2	3912	306	7.6
8×T9	2512	176	6.87
TR	1703	107	6.38
(KE×B2)×TR	2751	160	5.83
66	1410	67	4.84
(L×TR)×66	2906	142	4.84
TR×66	2819	122	4.37

The only remaining significant difference existing between these strains, table 1, is that existing between the hybrid 46×C2, having a survival of 7.6 per cent, and TR×66, which had a survival of 4.37 per cent.

Under the conditions existing in this experiment there were no real differences between the remaining strains of corn as regards their survival rates, as a difference of 3.23 per cent in this factor was necessary to indicate significance (*1*).

Experiments of 1933.—During this season 16 varieties were used in a randomized block arrangement with four replicates of each strain being provided. A rather large correction figure resulted so that a difference of 2.36 per cent in the survival figures was necessary to indicate significant differences in varietal resistance among the strains. In a summary, table 2, it will be seen that although two strains, namely B2×TR and TR×R4, are relatively low as compared to most of the other strains, these two strains are not significantly lower in this respect than a number of other strains occurring in the experiment. It was thought that considerable nonuniformity in the time of germination of the various replicates of each strain, resulting in a variable degree of maturity in the strains themselves, might have contributed to this condition. Clement's, a midseason strain, was again comparatively susceptible as indicated by its relatively high survival figure of 12.05 per cent.

[2] Grateful acknowledgment is made of the assistance and facilities provided for this work at Auburn by the Division of Entomology, State Department of Conservation, and at Monroe by the Monroe Laboratory of the Bureau of Entomology, U. S. Department of Agriculture.

Table 2.—Egg depositions, larval populations and survival rates on 16 strains of corn studied in 1933.

Variety or Strain	No. Eggs per 100 Plants	No. Borers per 100 Plants	Per Cent Survival
(L×TR)×66	643.8	49	7.61
Clement's White Cap	904.8	109	12.05
(66×TR)×H6	835.2	78	9.34
66×TR	539.4	44	8.16
(54×TR)×H6	957	68	7.11
C2×66	591.6	48	8.11
C2×TR	713.4	38	5.32
(C2×TR)×H6	800.4	48	5.99
B2×TR	574.2	20	3.48
(WC4×B2)×H6	962.2	51	5.53
(AH×76)×66	696	35	5.03
(A×L)×(66×TR)	755.2	63	8.34
(A×L)×TR	661.2	64	9.68
(A×TR)×Hy	730.8	64	8.76
(66×TR)×R4	609	42	6.89
Tr×R4	765.6	37	4.89

Experiments of 1934.—Data on survival during the 1934 season were procured on 20 strains of corn arranged in a randomized block with each strain occurring eight times in the experiment.

Among the group used, four strains stand out as indicating superiority over the remaining corns in having lower survivals. These strains are as follows: B2×TR, R4×TR, (Hy×R4)×(66×TR) and (66×R4)×TR, table 3. Under the conditions existing in this experiment, differences of .98 per cent in the rate of larval survival indicate significant differences among strains. Two midseason strains are again high in survival, these open-pollinated strains being markedly earlier in maturity than the remainder of the group. The remaining 14 strains may be arbitrarily

Table 3.—Egg depositions, larval populations and survival rates on 20 strains of corn studied in 1934.

Variety or Strain	No. Eggs per 100 Plants	No. Borers per 100 Plants	Per Cent Survival
66×TR	275.2	13	4.72
Woodburn Yellow Dent	206.4	15.75	7.63
(L×TR)×66	240.8	10.25	4.24
TR×L	240.8	9.34	3.88
Clement's White Cap	309.6	16.13	5.21
(A×L)×TR	68.8	3	4.35
A×TR	206.4	8	3.4
Bryant's Reid's Dent	283.2	10	3.51
(WC4×B2)×H6	378.4	10	2.64
66×L	137.6	5.34	3.88
Krug	378.4	16	4.23
(66×R4)×TR	202.8	4.22	2.08
R4×TR	172.4	3.75	2.18
(K×L)×66	275.2	11.8	4.29
B2×TR	137.6	1.34	.97
(W77×R4)×(66×Tr)	103.2	3.6	3.49
TR×Krug	137.6	4.7	3.39
(A×L)×(66×TR)	172	6.3	3.68
(Hy×R4)×(66×TR)	290	4	1.33
(I205×L289)×(66×TR)	240.4	9.4	3.39

classed as moderate with regard to resistance expressed as borer establishment and survival, with some of the strains approaching resistance and others approaching susceptibility. A large group, however, show no significant difference in survival under the conditions existing in this experiment.

Experiments of 1935.—The variety experiment of the 1935 season included 20 strains of corn, each of which was replicated 10 times and so placed as to form a modified Latin square.

In this work a difference of 1.61 per cent in survival between any two strains indicates significance. We may, therefore, conclude that several

Table 4.—Egg depositions, larval populations and survival rates on 20 strains of corn studied in 1935.

Variety or Strain	No. Eggs per 100 Plants	No. Borers per 100 Plants	Per Cent Survival
C2×66	213.6	20.25	9.48
(Hy×R4)×(66×TR)	142.4	6	4.21
Toben×H6	106.8	12	11.24
66×TR	106.8	9	8.43
66×L	391.6	39.25	10.02
(66×TR)×(A×L)	106.8	10.75	10.11
Krug	178	14	7.89
(L×TR)×66	106.8	10.25	9.55
TR×L	142.4	7	5
(A×L)×F	106.8	10.75	10.11
B2×TR	142.4	5	3.43
(H6×66)×TR	106.8	8	7.49
(66×TR)×F2	249.2	22.5	9.05
(66×TR)×P	106.8	10	9.36
Bryant's Reid's Dent	356	35	9.83
(66×WF9)×(R4×TR)	142.4	8	5.62
J. C. W. No. 1	249.2	19.5	7.87
Purdue 11	106.8	9	8.43
Clement's White Cap	320.4	43.75	13.67
TR×Krug	320.4	27.5	8.61

strains in the group, table 4, exhibit differences in survival which may be attributed to variety. As in the 1933 experiment, the strain B2×TR has been low in survival, but it is not significantly lower in this respect than the strain (Hy×R4)×(66×TR). These two strains, along with Tr×L and (66×WF9)×(R4×TR), form a group which seems to be significantly more resistant than the remaining 16 strains.

Discussion of strains.—Among the group of strains which, during these several tests, have appeared to show a greater degree of resistance to borer survival than the general group, the single-cross hybrid B2×TR appears to be outstanding. It seems probable, however, that lateness of maturity may play a part, at least, in giving this strain a high rating among those tested. Just how great a degree of the resistance is due to lateness or to what extent lateness is responsible for the apparent resistance has not been answered by the measurement of plant characters which have been a part of these studies. The remaining strains offering promise to resistance, namely Tr×R4, (66×R4)×TR, (Hy×R4)×(66×TR) and (66×WF9)×(R4×TR), have all silked and tasseled from one to three days earlier than B2×TR during comparable years in which two

or more of these corns have been used together and have apparently shown almost equal resistance.—4-28-36.

Literature Cited

(1) **Huber, L. L.** and J. P. Sleesman. Technique of field experimentation in entomology. II. The reduction of data by the method of analysis of variance. Jour. Econ. Ent. **28**(1):70–6. Feb.

(2) **Neiswander, C. R.** and L. L. Huber. Height and silking as factors influencing corn borer population. Ann. Ent. Soc. Am. **22**(3):527–42.

(3) **Patch, L. H.** Some factors determing corn borer damage. Jour. Econ. Ent. **22**(1): 174–83. Feb.

THREE FACTORS AFFECTING LABORATORY REARING OF EUROPEAN CORN BORER LARVAE

Ralph Mathes,[1] *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

A supply of parasites for utilization in biological control programs in certain cases may be obtained by rearing in the laboratory if a successful breeding technic can be developed. In the case of internal parasites, one of the problems encountered is that of rearing immature hosts of suitable quality and in sufficient numbers to enable parasite development to proceed unhampered by lack of host material.

Various experiments have been conducted to develop a satisfactory laboratory technic for the rearing of larvae of the European corn borer, *Pyrausta nubilatis* Hbn., intended as hosts for the rearing of certain internal parasites to be used in supplementing foreign importations. Three of the more important factors bearing on successful rearing of host material were studied during 1931 and 1932 at Monroe, Mich., and are discussed in this paper. These factors are (1) kinds of food, (2) space per borer in rearing trays, and (3) air circulation in rearing trays.

Methods and equipment.—All experiments were limited to the first 20 days of growth of the host larvae, as the majority of parasites which were under consideration complete development within this period. Each experiment was replicated four times, and the basis for appraising results was the percentage of larval mortality and the average weight of borers living at the end of 20 days.

Temperature and Relative Humidity.—Larvae in all experiments were reared in a room-size incubator at a constant temperature of 80° F and 70 per cent relative humidity. Previous experience had shown egg and larval development to be rapid at this temperature, but appreciably slower at lower temperatures.

Obtaining and Incubating Eggs.—For the oviposition cage an ordinary quart-size cylindrical ice-cream container made of cardboard was fitted with a 16-mesh wire screen top and bottom, fig. 1. The inside of

[1] The author is indebted to W. A. Baker, who initiated and directed the conduct of the experiments upon which this paper is based.

this cage was loosely lined with a sheet of ordinary bond typewriting paper. Ten male and 10 female moths were placed in each cage. A cotton pad saturated with water was kept on the tops of the containers throughout the period to provide moisture for the moths. Egg masses were deposited on the typewriting paper, which was removed every 24 hours and placed between two sheets of blotting paper saturated with water. An average of three and one-half days was required for the eggs to hatch.

REARING TRAYS.—The rearing tray, fig. 2, utilized in all experiments consisted of a rectangular frame 17 inches long, nine inches wide and two inches deep, inside measurements, constructed of one-half-inch wood. Except in the experiments on air circulation, when variations in the construction of top and bottom were necessary, the tray was completed as follows:

The bottom was covered with a piece of 80-mesh copper screen. The top consisted of a pane of single-weight window glass. A paper blotter

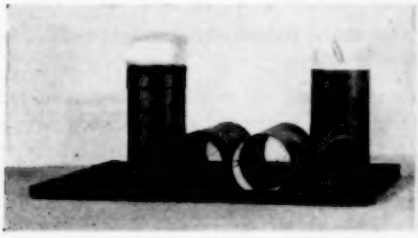

Fig. 1.—Oviposition cages.

Fig. 2.—Rearing trays.

equal in size to the outside of the frame was fitted over the tray and covered with the glass, both being held in place by three wooden strips and rubber bands. This functioned to absorb excess moisture and prevent the escape of young borers. The wooden strips were placed across the glass top, which was clamped in position by slipping the rubber band under the tray and looping it over the projecting end of each strip. The trays were supported in the incubator so as to allow ventilation from below.

FEEDING INTERVALS AND AMOUNT OF FOOD.—Food was supplied every five days, eight ounces of food being utilized for the first feeding and 12 ounces for subsequent feedings. Experience had shown that a shorter feeding interval was unnecessary and increased the work of rearing the larvae. A longer feeding interval had a decidedly detrimental effect on the borers, as a sufficient quantity of suitable food could not be maintained under the rearing conditions without occasional additions. The first feeding was scattered over half of the tray bottom. Most of the second feeding was scattered over the half not covered by the first feeding and the remaining portion was sprinkled over the first feeding. The third and fourth feedings were scattered over the first and second, respectively, with small portions of each being generally distributed in the tray. All unconsumed food, dead larvae and excrement were allowed to remain in the tray until the end of the rearing period.

Kinds of food.—Preliminary experiments were conducted on a total

Table 1.—Effect of food as indicated by mortality and weight of European corn borers. Average of four tests. The trays were kept in an incubator at 80° F and 70 per cent relative humidity and subjected to air currents from an electric fan operated eight hours a day beginning on the fifth day; 200 eggs ready to hatch were placed in each tray.

First Feeding	Second Feeding	Third Feeding	Fourth Feeding	Average Larval Mortality Per Tray, End of 20 Days		Average Weight of 20-day-old Borers, Grams	
				Number	Per Cent	Total Survivors	Per Larva
Beans, 1-inch sections	Beans, 1-inch sections	Podded peas with cut ends	Podded peas with cut ends	32.5	16.25	12.11	.072
Beans, 1-inch sections	Beans, 1-inch sections	Beans, 1-inch sections	Beans, 1-inch sections	38.75	19.37	10.73	.066
Beans, 1-inch sections	Podded peas with cut ends	Podded peas with cut ends	Podded peas with cut ends	43.75	21.88	7.1	.045
Podded peas with cut ends	Podded peas with cut ends	Podded peas with cut ends	Podded peas with cut ends	67	33.5	6.34	.048
Podded peas, 1-inch sections	Podded peas with cut ends	Podded peas with cut ends	Podded peas with cut ends	62	31	5.68	.041
Beans, 1-inch sections	Beans, 1-inch sections	Podded peas cut in middle	Podded peas cut in middle	71.25	35.62	5.51	.043
Cornstalks, 1-inch sections	Cornstalks, 1-inch sections	Cornstalks, 1-inch sections	Cornstalks, 1-inch sections	67	33.5	4.23	.032
Shelled peas	Shelled peas	Shelled peas	Shelled peas	118.5	59.25	2.42	.030
Dock	Dock	Dock	Dock	79	39.5	.75	.006
Cockleburs, 1-inch sections	Cockleburs, 1-inch sections	Cockleburs, 1-inch sections	Cockleburs, 1-inch sections	99	49.5	.52	.005

of 23 different foods or food combinations. Tests on 13 of these were discontinued when they were found unsuitable. String beans, green cornstalks and shelled peas, when shredded and used separately or in combination with corn meal, were unsatisfactory. The large amount of freshly cut surface produced by shredding caused the plant tissues rapidly to lose their juices, which first resulted in mold, followed later by excessive food dryness. These unfavorable conditions resulted in high morality rates among the first and second-instar larvae, with total inhibition of development beyond the third instar. Larvae failed to feed on young second-growth alfalfa or moist corn meal. A small amount of feeding was observed on sections of burdock stems, and a few borers reached the fourth instar on this diet. Fresh celery stalks and fresh spinach leaves decomposed rapidly with a resultant high larval mortality. The few borers that reached the fifth instar on such food were of inferior quality. Sections of green beans, mixed with sawdust to absorb excess moisture, and a food combination consisting of one-eighth-inch sections of green string beans for the first feeding, three-eighth-inch sections for the second feeding, and shelled fresh green peas for the remaining feedings, both proved to be poor, as the borers produced were not uniform in size and comparatively few survived. Shelled green peas, 1-inch sections of fresh green beans, and 1-inch sections of green cornstalk were most satisfactory in the first tests and were again tested in a final experiment, which included several new foods.

Results of these final tests, table 1, show that the food consisting of 1-inch sections of beans for the first two feedings followed by podded peas with cut ends for subsequent feedings resulted in the least mortality. With this diet the larval mortality at the end of 20 days was only 16.25 per cent, and the quality of the borers as indicated by their average weight of .072 gram was the best recorded in these experiments. This food combination makes available a large amount of tender bean surface that is readily eaten by the young borers. The podded peas used for later feedings possess considerable resistance to the rot and mold promoted by the increased feeding of the older larvae. The comparative ease with which borers can be removed from podded peas results in the saving of much time and work for the operator. Beans and peas have the added advantage of being available throughout the year.

Crowding of borers in rearing trays.—To test the effect of crowding borers in the rearing tray, five different populations were used. Trays were supplied with 100, 150, 200, 300 and 400 ready-to-hatch eggs per tray. All trays were subjected to air currents from an electric fan for eight hours a day beginning on the fifth day. Food consisted of one-inch sections of green string beans for the first two feedings followed by podded green peas with cut ends for later feedings.

Results of these experiments, table 2, show that the trays accommodated a maximum of 200 larvae over a rearing period of 20 days with no pronounced increase in mortality, although the quality of the borers, estimated by their average weight, decreased when the number of larvae was raised from 100 to higher populations. However, the total weight in each tray of 20-day-old borers increased as the number of larvae in a

tray was increased from 100 to 400. Trays started with 100 larvae incurred a mortality of 23.19 per cent over a 20-day period, and the borers living at the end of this time had an average weight of .073 gram each. Trays started with 400 larvae suffered an average mortality of 35.84 per cent at the end of a 20-day period, with the living borers averaging .047 gram each. The trays containing 200 larvae, intermediate between the above extremes, incurred a larval mortality of 26.75 per cent at the end of 20 days, and the borers averaged .055 gram in weight.

Air circulation in rearing trays.—The last factor to be tested was air circulation within the rearing trays. Six degrees of aeration were obtrained as follows: (1) using trays with solid tops and bottoms, (2) using trays with solid tops and screen bottoms, (3) using trays with screen tops and bottoms, (4) using trays with solid tops and screen bottoms and subjecting them to air currents produced by an electric fan for eight

Table 2.—Effect of crowding European corn borers in rearing trays as indicated by mortality and weight of borers.* Average of four tests.

No. Larvae per Tray	Average Larval Mortality per Tray at End of 20 Days		Average Weight of Surviving 20-day-old Borers, Grams	
	Number	Per Cent	Per Tray	Per Larva
100	23.19	23.19	5.59	.073
150	40.5	27	6.98	.064
200	53.5	26.75	8.03	.055
300	111	37	10.03	.053
400	143.37	35.84	12.11	.047

* The increased mortality and decreased weight of borers produced in these trays, as compared with results given in table 1 in a condition comparable with one of these, were probably the results of the accumulation of mites in the incubator at the end of the season when this experiment was conducted.

hours a day beginning on the fifth day, (5) using trays with screen tops and screen bottoms and subjecting them to air currents produced by an electric fan for eight hours a day beginning on the fifth day, and (6) using trays with screen tops and screen bottoms and subjecting them to air currents produced by an electric fan for 24 hours a day throughout the 20-day rearing period.

The fan used in these tests was 12 inches in diameter and had an air displacement of 835 cubic feet per minute. In the room-size incubator in which the experiments were conducted, it was placed approximately 5 feet from the trays. The air currents were made to strike a 3 by 4-foot sheet of galvanized steel, tilted at a 45-degree angle, which directed the air movement upward through the screen bottoms of the trays resting directly above on racks. Later tests made with a 16-inch, three-speed fan operated at medium speed only (1000 cubic feet air displacement per minute) and without the galvanized deflector, produced the same favorable results.

In all these tests the food provided was 2-inch sections of beans for the first two feedings followed by podded peas with cut ends for subsequent feedings.

The results of these experiments, table 3, show that a medium amount of air circulation was most satisfactory. This was obtained in those trays with solid tops and screen bottoms and in those with screen tops and

screen bottoms, both subjected to air currents produced by an electric fan running eight hours a day beginning with the fifth day of the rearing period. The borer mortality under these two similar conditions was 16.87 and 22.62 per cent, respectively, or an average of only 19.75 per cent. The average weight per borer was .063 gram. The increased or decreased circulation in the other types of trays resulted in increased larval mortality and decreased average weight of the surviving larvae. A medium amount of air movement within the rearing trays is necessary to drive off the excess moisture resulting from decomposition of the food. Failure to provide air circulation soon results in the decay of the food and a very unhealthy environmental condition. However, air circulation should not

Table 3.—Effect of air circulation as indicated by mortality and final weight of borers. Average of four tests. Each tray at the beginning of the experiment contained 200 eggs ready to hatch.

Type of Tray	Mechanical Air Circulation	Average Larval Mortality per Tray at End of 20 Days		Average Weight of Surviving 20-day-old Borers, Grams	
		Number	Per Cent	Per Tray	Per Larva
Solid top and bottom	None	164.34	82.17	1.42	.04
Solid top, screen bottom	None	99.37	49.68	4.58	.046
Screen top and bottom	None	84.25	42.12	5.46	.047
Solid top, screen bottom	Electric fan, 8 hrs. per day from 5th day	33.75	16.87	10.43	.063
Screen top and bottom	Electric fan, 8 hrs. per day from 5th day	45.25	22.62	9.92	.064
Screen top and bottom	Electric fan, 24 hrs. per day from 1st day	158	79	1.38	.033

be so great as to cause excessive drying of the food, since a certain amount of moisture is necessary for normal larval development.

The two extremes of air circulation, one with practically none, as obtained in those trays with solid tops and bottoms, and the other with an excess circulation, as in those trays with screen tops and bottoms subjected to air currents for 24 hours a day throughout the rearing period, gave the poorest results.

Summary.—A food combination consisting of 1-inch sections of cut green string beans followed by green peas in the pod with cut ends proved to be most satisfactory in the laboratory rearing of European corn borer larvae. This food, easily obtained throughout the year, resulted in a healthy larval development and a low mortality.

The effect of crowding in a rearing tray was to decrease the size of the borers when the number of larvae was increased beyond 100 and to increase the mortality as the number of larvae was raised from 200 to 300 or 400 per tray.

Air circulation within the rearing trays as obtained in those trays with solid tops and screen bottoms and those with screen tops and screen

bottoms, both being subjected to air currents produced by an electric fan operating eight hours a day beginning with the fifth day, proved most satisfactory. Less air movement resulted in molding and decomposition of food, while a greater circulation caused the food to become dry, hard, and unsuitable for the growing larvae.—1-4-36.

LARGER APPLE CURCULIO IN WISCONSIN[1]

P. O. RITCHER, *Kentucky Agricultural Experiment Station, Lexington*

Larger apple curculio, *Tachypterellus quadrigibbus magnus* List, has caused an increased amount of injury in recent years to western Wisconsin apple orchards. Although satisfactory control measures for codling moth and apple maggot have been worked out, present measures for combating the apple curculio under Wisconsin conditions are far from satisfactory.

A study of the apple curculio has been in progress for the last two years at one of Wisconsin's two stations for the investigation of orchard insects, which is located in the Kickapoo valley apple district near Gays Mills. Here are found approximately 1000 acres of apple trees which are all in sod.

Host-preferences.—In western Wisconsin the apple curculio feeds on wild hosts such as *Crataegus* and *Pyrus* and on the cultivated apple. McIntosh, Snow, Dudley, N. W. Greening, Wealthy and Duchess are the main commercial varieties of apples grown. Of these, Wealthy and McIntosh are most frequently attacked. Injury also occurs on Ben Davis, Wolf River, McMahon, Annison, Iowa Beauty, Transparent, Whitney, Hibernal, Patten's Greening, Pewaukee, Gravenstein, Golden Russet and Red Astrakan. Ben Davis is the most susceptible of all the varieties grown in the Kickapoo valley.

Type of injury.—Most of the injury caused by the apple curculio is the result of spring feeding and egg punctures made when the apple fruits are from one-fourth inch to an inch in diameter. When further growth occurs, probably because of injury to the vascular system, only the tissue surrounding each puncture grows and a crater is gradually formed with the old puncture at its bottom. The depth of the crater and the extent of the deformity depend on the time in the spring at which the apple was injured and the size of the apple. Gnarled and dwarfed fruits are the final result of early spring injury.

New generation feeding, which occurs in July, is not like that occurring in the spring, nor does the same type of deformity result. In this case, large surface areas are consumed and the excavations are shallow and often close together. The whole feeding area may become brown and shrunken. Such injury is most often seen at the stem or calyx ends of the fruits. Premature coloring usually follows where much late feeding has been done. This was noticed especially on Wealthy and Ben Davis.

[1] Published by permission of the Director of the Wisconsin Agricultural Experiment Station.

Life history.—Adult apple curculios appear in the spring at a time when the petals are starting to fall. This has varied from May 11 to May 31 during the past three years. The period of most active feeding and egg laying covers a period of two to three weeks and usually coincides with the occurrence of the first prolonged period of warm weather. This critical period in 1934 extended from May 26 to June 10 and in 1935 from June 8 to 28.

Eggs are deposited in vase-shaped cavities eaten out in the small fruits by the females and plugged with excrement. Usually for an egg to hatch and the larva to develop, the apple in which the egg was laid must cease active growth. Curculios develop almost entirely in drop fruit on the ground in the case of most varieties. In the case of Ben Davis at Gays Mills in 1935, approximately 16 per cent of the curculios developed in stunted fruits which remained on the spurs. The same phenomenon has also been observed occasionally on Wealthy and Wolf River.

The number of eggs laid by 21 pairs of curculios kept under observation in jelly glasses in 1934 ranged from two to 116 with a mean number of 39 per female. Counts made in 1935 on Ben Davis show that egg laying does not influence the drop of the fruit.

The young larvae hatches in four to eight days and feeds approximately 30 days on the seeds and surrounding tissue of the apple drop. A prepupal stage lasting one or two days precedes pupation. The pupal stage lasts four to eight days. The resulting adult remains in the drop or fruit on the spur three to five days before eating its way to the exterior.

New-generation adults often feed at first on the fruit from which they emerged. They soon migrate to fruits on the tree and feed for 10 to 30 days, with most of their feeding confined to the first two weeks.

In 1935 the first pupae were found July 6 and the first adult emerged July 12. By August 10, new-generation feeding was about over and most of the curculios had sought out hibernation quarters.

Hibernation.—Hammer (*1*) found that eastern apple curculios winter over on the ground beneath infested trees. In New York, in 1933, he screened 100 beetles from leaves and debris. The writer in 1934 placed a number of apple curculios in a screen cage over sod beneath a McIntosh tree. Seven curculios were recovered from this cage in the spring of 1935.

Apple curculios infesting *Crataegus* in the woods adjoining the orchards also winter over beneath the infested host. On May 7, 1935, an aster cloth cage was placed over a sawed-off clump of *Crataegus* where apple curculios had been common the year before. Twenty-eight small adults were collected from the cage between May 14 and June 2.

Parasites.—Two species of external hymenopterous parasites, identified by Muesebeck as *Microbracon tachypteri* Mues. and *Eurytoma tylodermatis* Ash., have been found parasitizing apple curculio larvae in Kickapoo valley orchards. Parasitism in certain orchards plays an important part in keeping the curculio population in check. In one lightly sprayed orchard in 1934, parasitism ranged from 40 to 63 per cent in a number of examinations of Wealthy drops collected beneath trees bordering a woods. Wealthy drops from border trees of a second orchard contained 36 per cent of parasitized individuals. Of the two parasites, the

smaller, a chalcid, *E. tylodermatis*, was more abundant in 1934. In 1935 the relationship was reversed.

Apple curculio larvae are the usual victims of the parasite larvae but occasionally a pupa is attacked. Twice cases were found where a larva of *E. tylodermatis* was feeding on a large parasite larva, probably that of *M. tachypteri*. *E. tylodermatis* forms a naked pupa, while the pupa of *M. tachypteri* is formed within an oval, light brown cocoon.

Control.—There are two times at which apple curculio adults might conceivably be controlled by spray materials. The first is in the spring during the spring feeding and egg-laying period. The second is during the short summer feeding period of the newly emerged adults.

Table 1.—Apple curculio plots, 1935, Gays Mills, Wis.

Treatment	Percentage of Infestation				
	Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean*
1. Lead arsenate 1:50, lime sulfur 1:50	14	9	1	1.5	6.37
2. Lead arsenate 2:50, lime sulfur 1:60	12	50	13	13.5	22.12
3. Calcium arsenate 1:50, lime sulfur 1:60	3.5	10	5	3	4.25
4. Derris-pyrethrum 1:300, aqueous spray	8	29	23	3	15.75
5. Check	16	43	0	9	17
6. *Black Leaf 155*	45	5	2.5	3	13.87
7. Manganese arsenate 1:50, lime sulfur 1:60	24	12	1.5	41	19.62
Mean	17.5	22.5	5.9	10.6	14.13

Variance Due to	Sum of Squares	Degrees of Frequency	Mean Square
Blocks	1137.78	3	379.26
Treatments	1051.12	6	175.18
Error	3705.13	18	205.84

* Difference between treatment means necessary to give significant odds 24.8 per cent.

A spray consisting of lead arsenate 3:50 plus one-fourth pound of dried milk was applied to a 10-acre block of heavily infested Ben Davis trees August 2, 1934, in an attempt to stop new-generation curculio feeding and cut down the 1935 population. Observations after spraying showed that the feeding was checked. Feeding was reduced by 65 per cent and 27 per cent of the beetles were killed in laboratory tests made with the same material.

The results of this treatment were evident in the spring of 1935. Counts of spring and summer injury made on 14 trees heavily infested in 1934 showed a total reduction of from 25 per cent injured fruits in 1934 to 7 per cent in 1935. Curculio injury appeared at the old level in untreated orchards.

Under existing tolerance requirements for lead and arsenic, it would be inadvisable to apply such a heavy dosage as a means of new generation control unless the fruit could be washed. Even in the case of Ben Davis, a late variety, the amount of residue at picking time was objectionable.

Several samples picked on October 10 had an average of .026 gr. of lead per pound of fruit and .010 gr. of arsenic.

A number of replicated spray plots of seven treatments each were laid out early in the spring of 1935 in an area of heavy infestation in the Ben Davis block mentioned above. Each plot consisted of two trees and each plot was replicated four times. Lead arsenate 1:50 plus lime sulfur 1:50, calcium arsenate 1:50 plus lime sulfur 1:60, manganese arsenate 1:50 plus lime sulfur 1:60, *Black Leaf 155* and an aqueous derris-pyrethrum spray at 1:300, were applied on June 10–11 and 22, at which times curculio feeding was just starting in the block and near its peak respectively. Lead arsenate 2:50 plus lime sulfur 1:60 was applied only on June 10–11. The check plots received no spray at these critical periods but did receive a calyx spray on June 1 in common with the arsenical plots.

Counts of injured fruit were made October 14 and 15 by picking a vertical sector of two pails of apples from each tree. One hundred apples from each tree of each two-tree plots were examined for curculio injury, making a total of 200 apples examined from each plot. Table 1 gives the

Table 2.—Repellence of arsenicals to the apple curculio, August 2–11, 1935.

	No. Curculios	No. Punctures	No. Dead
Oleated lead arsenate 2:50	20	317	2
Iron-coated lead arsenate 2:50	20	342	2
Check, no special spray	20	759	0

percentage of injury for the various blocks. Although treatments 1 and 3, consisting of lead arsenate and calcium arsenate, had low percentages of injury this year, an examination of these data by the method of analysis of variance indicates that the differences found between the various plots cannot be considered highly significant. This should be taken care of in the future by increased replication of plots to reduce the random error.

Laboratory tests were made with oleated lead arsenate 2:50 and iron-coated lead arsenate 2:50, using 20 new-generation curculios in each case, in an attempt to find out whether the repellent effect of ordinary lead arsenate could be overcome. The materials tested had little lethal effect but had a marked repellent effect, table 2. The amount of repellence was about equivalent to that found for a dosage of 3 pounds of lead arsenate in 1934.

Since the amount of deformity of the apple fruit resulting from injury by the apple curculio depends upon the size of the fruit, a delay in the time of attack might mean the difference between a cull fruit or a marketable one. The application of a good repellent at the critical spring period might be of great benefit.

A series of aromatic fermenting baits was exposed in 16 granite ware hootch pans from May 19 to June 12 in an attempt to attract apple curculios. The materials used were oil of sassafras, oil of citronella, anise, ethyl cinnamate, eugenol, oil of mace, safrol, and checks. The aromatics were added to the standard codling moth bait at the rate of five crops to a pan. Not a single apple curculio was found in the traps.

Removal of wild host.—A study was made of the population of apple

curculios on wild hosts to find out whether their removal would act as a control measure, as is often advocated. It was found that curculios reared from *Crataegus* and curculios taken on *Crataegus* shortly after the emergence of the new generation are much smaller than those reared from cultivated apple or taken on apple at the corresponding time. Because of this fact the annual crossover from wild host to cultivated host in nature can be measured by making collections through the season and comparing the sizes of the individuals found on the various hosts.

From a comparison of spring collections made on *Crataegus* and on apple, it appears that there was some transfer in nature in 1934–1935 from wild to cultivated hosts and vice versa. This was not enough to be of much importance. There is not more crossover since apple curculios have feeding and egg-laying preferences for the hosts on which they occur. Too, it has been shown that apple curculios tend to reinfest the same trees year after year, wintering over on the ground beneath.

By these results it would appear that wholesale removal of wild hosts would not reduce the number of curculios now in apple orchards but might actually increase the population by forcing over curculios that would normally confine themselves to the wild host.—1-4-36.

Literature Cited

(*1*) **Hammer, O. H.** 1933. Further studies on the control of the apple curculio in the Champlain valley. Jour. Econ. Ent. **26**(2):420–4. 4 figs. Apr.

PUPAL PERIOD OF THE HESSIAN FLY

H. H. Walkden, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*[1]

In the extensive literature on the Hessian fly, *Phytophaga destructor* (Say), only brief reference to the pupa and to the time spent in this stage can be found. Criddle (*1*, p. 11) states that the pupal stage is of short duration. Gossard and Houser (*2*, p. 7) note that the pupa usually remains within the puparium 10 or 12 days. McColloch (*3*, p. 35) brought infested material into the greenhouse in winter and found the average time between collection and emergence to be 18.9 days with extremes of eight and 36 days. Osborn (*4*, p. 18) observes that after the formation of the pupa a variable period is spent within the puparium, the issuance of the pupa doubtless depending on favorable temperature. Packard (*5*, p. 12) placed opened puparia in vials and observed the pupal periods of individuals, the average being 22 days, with a range from nine days in May to 40 days in midwinter at Sacramento, Calif. Rockwood and Reeher (*6*, pp. 8–9) state that the duration of the pupal stage in the Pacific northwest in September is about 12 days and is largely dependent on temperature, being longer early in the spring.

In connection with the writer's observations on the seasonal history of the Hessian fly in Kansas it appeared that there was considerable variation in the length of the pupal period. To secure more definite in-

[1] The data on which this paper is based were secured while the writer was under the direction of J. R. Horton at Wichita, Kans.

formation on the length of this stage a number of puparia were collected just before pupation time in the spring and fall and the end of each of them opened sufficiently to permit observation of the larva within. They were then put in small vials plugged with cotton and these placed in holes bored in plaster of Paris blocks, the plugged end of each vial being in contact with the plaster. Moisture was supplied by absorption from the plaster, which was kept nearly saturated by setting the blocks in shallow pans of water every day or two and allowing the plaster to soak up as much water as possible. In this manner fairly favorable moisture conditions were maintained. The puparia were kept in an outdoor, unheated insectary the temperature of which is believed to have averaged slightly warmer than actual outdoor temperatures.

Table 1.—Summary of pupal period of the Hessian fly.

	No. Days as White Pupa	No. Days as Red Pupa	No. Days as Black Pupa	Total No. Days as Pupa*	No. Females	No. Males
			Fall-emerging Flies			
Maximum	5	11	6	14		
Minimum	1	1	1	6		
Average	2.3	4.7	2.1	8.9	96	37
			Spring-emerging Flies			
Maximum	19	15	7	33		
Minimum	1	1	1	7		
Average	5.7	8.6	2.8	17.1	105	90

* Total days as pupa is not a summation of the three preceding columns; for example, in the first instance no individual required the maximum number of days indicated in the three pupal forms.

Observations on fall-emerging flies.—Observations were made on the pupal period of fall-emerging flies during the years 1923, 1924, 1927 and 1928. Early in September puparia were removed from wheat stubs that had passed the summer in the field. After the puparia were opened to expose the larvae they were placed in individual vials, daily observations made, and the pupal development recorded under the following headings: (1) date of pupation, (2) date of assuming red coloration, (3) date pupa became black, and (4) date of emergence of adult fly.

There was considerable mortality in the puparia opened for observation. Many of the larvae crawled out of the open puparium and either rested on the cotton plug or attempted to burrow into the cotton. Out of 310 puparia under observation 133, or 43 per cent, yielded adults, of which 72 per cent were females. In table 1 is a summary of the results of the observations on the fall-emerging flies. It will be seen that the length of the pupal period was from six to 14 days, the average for the whole group being 8.9 days.

When the pupa is formed it is pearly white, changing gradually to light pink. In one to five days the pinkish tinge gives way to a decided reddish color. The pupa remains in this stage one to 11 days. The final stage is characterized by the wing pads becoming black and the abdomen blackish, tinged with red. The pupa remains in this stage one to six days and then the adult emerges. The rapidity with which these changes occur seems to be largely dependent on the temperature.

To determine the influence of temperature on the length of the pupal stage the mean temperature for the period from date of pupation to emergence of adult was calculated for each individual. The daily means were secured from the records of the Weather Bureau, U. S. Department of Agriculture, for Wichita, Kans. The data thus obtained were grouped in 3-degree class intervals of temperature. The mean length of the pupal period and the mean temperature were calculated for each group, with the results shown in table 2. Thus at a mean temperature of 59.6° F the pupal period for 31 individuals averaged 11.3 days, while at 66.3° F the average for 40 individuals was 7.5 days. It is probable that a mean temperature of 73° F approaches the temperature of aestivation, when no further pupation would occur.

Table 2.—Relation of temperature to the length of the pupal period of the Hessian fly.

Temperature Interval °F	No. Individuals Observed	Group Mean °F	Mean Pupal Period, Days	No. Individuals Observed	Group Mean °F	Mean Pupal Period, Days
	Spring-emerging Flies			*Fall-emerging Flies*		
38–40	13	39.2	31.5			
41–43	10	41.5	26.6			
44–46	20	45.6	20.2			
47–49	57	47.7	18.5			
50–52	42	50.4	14.7			
53–55	38	54.5	11.4			
56–58	12	56.6	11.2			
59–61	1	60	8	31	59.6	11.3
62–64	2	63	8	44	63	9.4
65–67				40	66.3	7.5
68–70				17	68.6	7
71–73				1	73	6

Observations on spring-emerging flies.—Observations on the pupal period of spring-emerging flies were made during the years 1924, 1927 and 1928. During the first week in March puparia were secured from infested plants that had passed the winter in the field. The puparia were given the same treatment as for the fall emergence. The mortality in the spring group was much less than in the fall group. Altogether, 260 puparia were observed, and 195, or 75 per cent, produced adults. Of these, 54 per cent were females. In table 1 is also a summary of the results of the observations on spring-emerging flies. The length of the pupal period ranged from seven to 33 days, the average for 195 individuals being 17.1 days, nearly twice as long as for the fall brood of flies. The stages in the development of the pupa are correspondingly longer, the greatest differences being in the white and red stages.

The mean temperature for each individual pupal period was calculated as noted previously, and the data grouped in the same manner as for fall-emerging flies. The results are given in table 2. The influence of temperature on the length of the pupal period is well defined. Thus, at a mean temperature of 39.2° F the pupal period for 13 individuals averaged 31.5 days, while at 50.4° F it is shortened to 14.7 days. It is probable

that a mean temperature of 39° F approaches developmental zero, as evidenced by the rapidly increasing pupal period as the mean temperature falls below 50° F.

Summary.—Observations made on 328 Hessian fly pupae showed the duration of the pupal period to range from six to 33 days. The pupal period for fall-emerging flies was much less than for spring-emerging flies. The length of the pupal period is largely influenced by the temperatures prevailing during that period.—1-4-36.

Literature Cited

(*1*) **Criddle, Norman.** 1915. The Hessian fly and the western wheat-stem sawfly. Can. Dept. Ag. Ent. Branch Bul. **11.** 23 pp., illus.

(*2*) **Gossard, H. A.** and J. S. Houser. 1906. The Hessian fly, *Mayetiola destructor* Say. Ohio Ag. Expt. Sta. Bul. **177.** 40 pp., illus.

(*3*) **McCulloch, J. W.** 1923. The Hessian fly in Kansas. Kans. Ag. Coll. Ag. Expt. Sta. Tech. Bul. **11.** 96 pp., illus.

(*4*) **Osborn, H.** 1898. The Hessian fly in the United States. U.S.D.A. Div. Ent. Bul. **16** (n.s.). 58 pp., illus.

(*5*) **Packard, C. M.** 1928. The Hessian fly in California. U.S.D.A. Tech. Bul. **81.** 26 pp., illus.

(*6*) **Rockwood, L. P.** and M. M. Reeher. 1933. The Hessian fly in the Pacific northwest. U.S.D.A. Tech. Bul. **361.** 24 pp., illus.

HORDEUM GRASSES AS HOSTS OF THE HESSIAN FLY

E. T. Jones, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Hordeum pusillum Nutt., or little barley, a wild native annual grass widely distributed throughout the United States (*1*) and especially abundant in the central wheat-growing area, is under some conditions the foremost wild-grass host of the Hessian fly.

By carrying over fly populations which later reinfest wheat, it, with other wild-grass hosts, becomes a factor that tends to operate against the success of delayed seeding and crop rotation as control measures for the Hessian fly.

Unlike various species of *Elymus* and *Agropyron*, previously reported as hosts (*2*) of the Hessian fly, *H. pusillum* thrives on cultivated land. It grows among the wheat, when the stand of grain is sparse, producing a crop of seed which, early in the fall, often when moisture is insufficient to germinate wheat, develops into a thick, almost imperceptible stand of hairlike grass able to receive eggs and support infestation from the first fall brood of flies before wheat has been seeded or has sprouted.

In the literature reviewed no reference to the native wild species of *Hordeum* as hosts of the Hessian fly has been found. It is probable that the small size of the plants in the fall, their inconspicuous appearance, and their habit of disintegrating late in the spring have masked their potentialities as fly hosts.

At Enid, Okla., in 1927, the writer, while examining wheat fields dev-

Fig. 1.—Little barley, *Hordeum pusillum*. ×½.

astated by second-brood Hessian fly, observed that *Hordeum pusillum* plants growing among the wheat were also heavily infested with the puparia of the fly. Because the significance of this discovery was not immediately apparent, no field studies were made at that time. However, 250 culms collected for laboratory examination yielded 50 puparia from a 7.6 per cent stem infestation.

Table 1.—Infestation found in field collections of *Hordeum pusillum*.

Year	Date Collected	No. Samples	No. Plants Examined	Per Cent Plants Infested	No. Tillers Examined	Per Cent Tillers Infested	Average No. Puparia per Infested Tiller	Total No. Puparia
1927	6/9	1	69	20.2	250	7.6	2.6	50
1928	1/26–3/27	6	2583	4.6	13,072	1	1.6	212
1932	5/20–23	5	609	2.1	1955	.7	1.2	15
1933	2/24–3/3	3	588	1.2	1491	.5	1.3	9
1934	3/22	2	184	0	1600	0	0	0
Totals		17	4033		18,368		1.7	286
Average, 5 years		*3.4*	*807*	*3.8*	*3673*	*.9*	*1.8*	*57.2*

During the following seven years field collections of *Hordeum pusillum* plants were made from time to time and examination made for infestation. The results of these examinations are given in table 1. With the exception of the 1927 record from Enid, Okla., all collections were made from wheat fields in the vicinity of Wichita, Kans. Infestations of the Hessian fly in wheat in this area in 1929, 1930 and 1931 were extremely low, and during these years no appreciable infestations in *Hordeum pusillum* were observed.

Artificial infestation in the field.—Early in October 1927 an experiment was made with artificially infested *Hordeum pusillum* in the field. A natural growth of *H. pusillum* in fence rows was covered with cages, and Hessian flies bred from wheat were introduced. As a result of burning over the field three weeks earlier the plants were thickly seeded, small, and very young.

Table 2.—Artificial infestation of *Hordeum pusillum* seedlings in field, fall of 1927.

Plot No.	Pairs of Flies Introduced	Date Introduced	Date Examined	No. Plants Examined	Per Cent Plants Infested	No. Tillers Examined	Per Cent Tillers Infested	Average No. Puparia per Infested Tiller	Total No. Puparia
1	22	10/13	1/31	682	4	2032	1.3	1.3	36
2	31	10/7	1/20	1153	6.5	3319	2.3	1.2	97
Total or Average	*53*			*1835*	*5.6*	*5351*	*1.9*	*1.3*	*133*
Check	0	0	1/30	423	.7	1276	.3	.1	3

In January of the following year, 2 square feet of grass from each plot were examined, with the result that 133 puparia were found to have been produced from eggs deposited on the primary leaves of these plants. It is evident therefore that *Hordeum pusillum* plants can support appreciable infestations of the Hessian fly even when very small. The detailed results of the examination of the plants from the two plots are shown in table 2.

Although several of the observed field infestations were undoubtedly of spring origin, a majority of the early field observations were made on

plants infested primarily by fall-brood Hessian flies. To determine whether *H. pusillum* could be as readily infested by spring-brood Hessian flies, 1 by 6-foot plots of natural-growth *H. pusillum* were laid off in the alleys between experimental wheat plots at Wichita, Kans. Four of these were exposed to infestation under muslin-covered wooden cages. The fifth plot was left as a check. The plots were watered during the periods

Table 3.—Infestation of *Hordeum pusillum* plants with spring-brood Hessian flies.

Plot No.	Date Flies Introduced	Pairs of Flies	Date Examined	No. Plants Examined	Per Cent Plants Infested	No. Tillers Examined	Per Cent Tillers Infested	Average No. Puparia per Infested Tiller	Total No. Puparia
1	3/15	30	4/27	160	40	748	12.5	2.1	198
2	3/18–4/17	65	5/3	143	44	870	11.2	2.3	253
3	4/1 –4/17	70	5/10	142	45.5	1041	12	3.1	378
4	4/6 –4/11	75	5/17	148	57	821	14.7	3	359
Total or Average		*240*		*593*	*46.5*	*3580*	*12.5*	*2.7*	*1188*
Check		0	5/1	124	2.4	1593	.4	1.5	9

of oviposition and larval migration. After puparia had developed all plants were dissected for records of infestation. As shown in table 3 it was found that in the four plots from 40 to 57 per cent of the plants and from 11.2 to 14.7 per cent of the tillers were infested.

In order to obtain additional evidence numerous tests were made with *Hordeum pusillum* plants grown in pots and caged with Hessian flies. In 1927 plants were grown in 6-inch pots and infested under lantern globes; in 1929 wire cages and 12-inch pots were used; in 1932 and 1933 infestations were obtained under wire cages over 10-inch metal flats. In 1927, 4.6 per cent; in 1929, 8.8 per cent; in 1932, 14.4 per cent; and in 1933, 30.2 per cent of the eggs deposited on the plants developed into

Table 4.—Potted *Hordeum pusillum* plants infested with Hessian fly.

Year	No. Pots	Pairs of Flies	No. Eggs	Per Cent Eggs Producing Pupae	No. Plants Examined	Per Cent Plants Infested	No. Tillers Examined	Per Cent Tillers Infested	Average No. Puparia per Infested Tiller	Total No. Puparia
1927	10	32	1840	4.6	91	28.5	295	10.5	2.7	85
1929	4	50	1062	8.8	204	23.5	299	19	1.6	93
1932	3	20	871	14.4	55	73	146	31.5	2.7	125
1933	3	20	880	30.2	87	65.5	601	13.5	3.4	266
Total	20	122	4653		437		1341			569
Average, 4 years	*5*	*30.5*	*1163.2*	*12.2*	*109.2*	*39.1*	*335*	*16*	*2.7*	*142.2*

puparia. The puparia produced in the 1927 and 1929 series of pots were smaller and less viable than those produced in the 1932 and 1933 series. These differences are attributed to toughened plant tissues in the 1927 and 1929 series, which were grown thickly under semiarid conditions. This was in contrast to the succulent condition of the plants in the 1932 and 1933 series, which were spaced and supplied with adequate moisture. Details of these pot tests are given in table 4.

Hordeum pusillum plants growing among wheat were observed to be generally less infested with puparia than those on the edge of the field. This difference was attributed to selective oviposition. In order to de-

Table 5.—Comparative attractiveness of wheat and *Hordeum pusillum* and other grasses for oviposition by the Hessian fly.

Host Plant	No. Plants	No. Plants Infested with Eggs	Per Cent Plants Infested with Eggs	Total No. Eggs Deposited
Kanred wheat	30	30	100	453
Hordeum pusillum	30	30	100	424
Aegilops cylindrica	30	27	90	398
Elymus virginicus	30	23	77.7	264
Bromus secalinus	30	21	70	97
Hordeum jubatum	30	20	66.7	99
Bromus tectorum	30	5	16.6	22
Oregon rye grass	30	5	16.6	12
Italian rye grass*	30	3	10	6

* *Lolium multiflorum.*

termine the comparative attractiveness for oviposition of *H. pusillum* with other wild grasses and with Kanred wheat a triplicate series of 10 plants each of wheat and of eight species of grasses was exposed in a single flat to 10 pairs of Hessian flies bred from wheat. A careful count was made of the number of eggs deposited on each plant, with the result that, as indicated by the data of table 5, *Hordeum pusillum* was slightly less attractive for oviposition than wheat, but considerably more attractive than some of the seven other grasses included in the test.

Other species of *Hordeum* as hosts of the Hessian fly.—In addition to *Hordeum pusillum*, *H. jubatum*, *H. murinum*, *H. nodosum*, *H. gussoneanum*, *H. maritimum*, *H. bulbosum* and other native wild species of *Hordeum* having a more limited range of distribution, are also potential hosts of the Hessian fly. Study of the reaction to Hessian fly attack of 15 species and strains of wild *Hordeum* was made during the spring of 1935. Identified plants used in leaf-rust investigations were supplied for the test by C. O. Johnston of the U. S. Department of Agriculture, Bureau of Plant Industry. The plants in 2½-inch pots were uniformly

Table 6.—Reaction of species and strains of *Hordeum* to Hessian fly attack.

	Source or Strain	No. Plants Examined	Per Cent Plants Infested	No. Tillers Examined	Per Cent Tillers Infested	Average No. Puparia per Infested Tiller	Total No. Puparia	Injury to Plant
Hordeum nodosum	Idaho	47	6.4	70	4.3	1.3	4	None
H. murinum	Calif.	26	34.6	55	16.4	2.9	26	Slight
H. pusillum pubens	CI6068	16	50	50	20	1.4	14	Slight
H. pusillum	Native Kansas	57	35	98	22.4	2.8	61	Moderate
H. pusillum	CI6078	18	77.7	61	26.2	2.4	38	Slight
H. gussoneanum	CI6066	30	53.3	59	28.8	1.7	30	Moderate
H. murinum	CI4102	13	92.3	55	29.1	2.2	35	None
H. murinum	CI4278	34	82.4	88	37.5	3.5	116	Severe
Wheat check	Marquis	3	100	13	38.5	2.6	128	Moderate
H. maritimum	Calif.	16	87.5	41	43.9	2.8	50	Severe
H. bulbosum	Calif.	11	100	58	44.8	2.5	64	Slight
H. jubatum	Calif.	20	85	52	46.2	2.2	53	Severe
H. jubatum	Calif.	32	94	65	53.8	3.7	128	Severe
Wheat check	Kanred ×Gipsy	5	100	37	54.1	8	161	Moderate
H. spontaneum	CI2294	13	100	63	60.3	4.5	167	Slight
H. murinum	Calif.	32	68.7	44	61.4	5.2	139	Severe
H. gussoneanum	CI6067	18	94.4	46	73.9	3.8	129	Severe

Fig. 2.—Infested plant of *Hordeum pusillum* and Hessian fly puparia reared on it. ×3.46.

distributed in triplicate series in a large flat, which was then filled with sand to the top of the pots. Three hundred puparia were spread over the sand in the center of the flat. The flies emerged as in nature, and eggs were deposited on the various species of grasses without apparent dis-

crimination. Grasses with pubescent leaves were as heavily infested with eggs as those with smooth leaves, which received almost as many eggs as the wheat checks. A muslin-covered cage was kept over the plants until after larval migration. The plants were studied and dissected for infestation after the larvae had matured. The susceptibility of all these species to infestation by the Hessian fly is indicated by the data of table 6. Species and strains of these grasses were found to differ as widely in their reaction to Hessian fly infestation as species and strains with species of wheat. Hessian flies from wheat have been used in all infestations reported in this paper.

That flies bred on *Hordeum pusillum* can reinfest wheat was demonstrated in 1933 when, under difficult conditions, 59 puparia were producted on wheat from eggs deposited by flies reared on *H. pusillum* and 22 puparia from flies from *H. jubatum*.

Summary.—Susceptibility to infestation, wide distribution, and life habits similar to winter wheat make *Hordeum pusillum* an important potential host capable of maintaining populations of the Hessian fly in the absence of wheat.

Hordeum pusillum is slightly less attractive than wheat for oviposition by the Hessian flies reared from wheat, but is more attractive than *H. jubatum*, *Aegilops cylindrica*, *Elymus virginicus*, *Bromus secalinus*, *B. tectorum*, and Oregon or Italian rye grass. It is probable that host selection is an influencing factor.

Puparia produced on *H. pusillum* grown under semiarid conditions are smaller than puparia from wheat. However, plants grown in moist soil produce normal puparia.

Pot tests involving a total of 15 strains of *Hordeum pusillum*, *H. jubatum*, *H. nodosum*, *H. murinum*, *H. maritimum*, *H. gussoneanum* and *H. sponataneum* reveal these wild grasses to be fly hosts but varying somewhat in their susceptibility.—7-9-36.

Literature Cited

(*1*) **Hitchcock, A. S.** 1935. Manual of the Grasses of the United States. U.S.D.A. Misc. Pub. **200**:265–8. Feb.

(*2*) **Noble, W. B.** 1931. Two wild grasses as hosts of the Hessian fly, *Phytophaga destructor*. Jour. Ag. Res. **42**(9): 589–92. May.

INFLUENCE OF CERTAIN FACTORS ON OVIPOSITION RESPONSES OF THE CHERRY CASE-BEARER[1]

John H. Lilly, *University of Wisconsin, Madison*

Cherry case-bearer, *Coleophora pruniella* Clem., has been a subject of investigation in the Door peninsula area of Wisconsin for the last several years. A physiological phase of this study has been an attempt to determine the influence of certain environmental factors on the oviposition

[1] This paper is published with the approval of the Director of the Wisconsin Agricultural Experiment Station.

responses of the female moths. Fungicide residues on, and vegetative condition of, prospective host trees are the factors which have been most thoroughly investigated.

The method was simply to select small branches at random on different trees in the respective plots, count the number of leaves per branch, and also the number of eggs on these leaves. From these figures the average number of eggs per leaf was readily computed. The number of leaves counted on each fungicide plot was 500 in 1933 and 2000 to 2900 in 1934 and 1935.

The fungicide plots were located in the same Montmorency cherry orchard over the three-year period, and were shifted about from year to year. These plots were sprayed and cared for by the Department of Plant Pathology of the University of Wisconsin, and were made available

Table 1.—Average numbers of case-bearer eggs per leaf on Montmorency cherry plots.

	1933	*1934*	*1935*	MEAN
Unsprayed		2.76	2.38	2.57
Bordeaux 1, 2, 3*	.52 .98	.77	.7	.74
Bordeaux 1, 2 delay, 3	1	1.59		1.29
Bordeaux 1, 2	.96	1.37	.24	.86
Bordeaux 2 delay, 3		1.22		1.22
Bordeaux 1 delay, 2			.52	.52
Flotation sulfur 1, 2, 2a, 3	1.42	2.42	1.07	1.64
Lime sulfur 1, 2, 3	1.08	2.26	.92	1.42
Lime sulfur 1, 2, 2a, 3	1.55	2.9	.63	1.69
Copper phosphate 1 delay, 2, 3			.79	.79
Basi-Cop 1, 2, 3			.83	.83

* The numbers 1, 2, 2a and 3 in the respective headings designate the four regular Wisconsin cherry sprays: *i.e.*, petal fall, 10-day, before harvest, and after harvest.

to the writer for this work through the courtesy of Dr. G. W. Keitt and Dr. E. C. Blodgett. Credit is also due to Dr. Blodgett for the original observation of variations in degree of case-bearer infestation among his 1933 plots.

Data collected over the three-year period show marked variations in the average numbers of case-bearer eggs laid per leaf on trees treated with different fungicidal spray programs. Quite consistently unsprayed trees had the highest average numbers of eggs per leaf; trees sprayed with sulfur compounds came next; and plots receiving treatments with copper compounds had the lowest averages. Observations in commercially sprayed orchards also tend to substantiate this generalization. The experimental sulfur treatments consisted of lime sulfur in two different programs and flotation sulfur in a full four-treatment program. The copper-sprayed plots included Bordeaux mixture in five different programs and single plots of copper phosphate and *Basi-Cop*. Arsenate of lead was used in similar concentrations (usually three-fourths pound to 50 gallons) in all treatments. Unfortunately, counts were not made on unsprayed check trees in 1933. Table 1 lists the results of all counts made where comparisons of different fungicidal spray programs were involved.

Studies on trees in different conditions of growth.—In 1934 two 6 by 6-foot cheesecloth cages were constructed so as to cover four young

trees of different species, all known to serve as hosts to the case-bearer. Moths reared on apple were placed in one cage and those reared on cherry in the other. The original object was to determine whether moths reared on apple tend to oviposit on apple, and vice versa. Preliminary results indicated that these moths prefer to oviposit on the available host trees which are in the most succulent condition of growth.

This theory that vegetativeness is conducive to case-bearer oviposition was further tested this year with nitrogen fertilization and excessive pruning of a few trees in commercial orchards in early spring, and counting the eggs as described above in August. It was found that the average number of eggs per leaf was markedly increased where additional growth was stimulated by either method. This is in accord with previous ob-

Table 2.—Average numbers of case-bearer eggs per leaf on Montmorency cherry trees in modified conditions of growth, 1935.

Treatment	Place	Number Trees	Total Leaves	Total Eggs	Average No. Eggs per Leaf
Unfertilized check	Bingham	2	3319	2615	.79
Ammonium sulfate 3 lbs. per tree	Bingham	2	3194	3295	1.03
Ammonium sulfate 6 lbs. per tree	Bingham	2	3306	4643	1.4
Unfertilized check	Learned	4	1999	443	.22
Sodium nitrate 2 lbs. per tree	Learned	4	1840	466	.25
Sodium nitrate 4 lbs. per tree	Learned	4	2014	622	.31
Unpruned check	Bingham	2	3252	2216	.68
Heavily pruned	Bingham	2	3276	2669	.82

servations which have indicated that young and rapidly growing cherry trees are more heavily infested than are adjacent mature trees. These results are listed in table 2.

Similar egg counts were made in 1935 on apple trees located in a row extending in opposite directions from an electrocuting light trap which killed large numbers of case-bearer moths. No definite trends were conclusively disclosed by these data.

It has been observed (*2*) that many leaves on heavily infested trees turn yellow and drop soon after the hatching period, when the young larvae are feeding in numbers. This is especially true of the sour cherry and certain varieties of apples, notably the Hyslop Crab. In 1934 egg counts were made on yellow, partly yellow, and green leaves on both Montmorency and Hyslop trees. On eight plots the yellow and partly yellow leaves averaged two to seven times as many eggs per leaf as did the green leaves on the same branches. Further proof that the presence of the young larvae causes yellowing and subsequent premature fall of leaves was furnished by observations of various leaves which were yellow on one half where several larvae were located and green on the opposite half where few or no larvae were present. Since these young larvae are unable to regain their positions on the trees after being dropped to the ground, this tree reaction often serves materially to reduce heavy infestations, although it is more or less directly detrimental to the tree.

Theoretical considerations.—Richardson (*4*) thoroughly covered the literature published previous to 1925 on the oviposition responses of insects and concluded that "most free-living insects require a chain of stimuli to provoke egg laying." He put considerable emphasis on the influence of odorous substances but pointed out that while these may be attractive to gravid females, odor is probably never in itself sufficient to induce normal oviposition. Brues (*1*) stated that "there is much in the behavior of certain species to suggest that food plants are selected on the basis of odor by the parent female." In addition, he recognized "some attribute of the plant, perhaps an odor but far less pronounced to our senses than odor or taste" as a factor in the attraction of insects to some plants. Moore (*3*) has recently presented evidence to show that infestations of potato aphids were more severe on Bordeaux-sprayed than on check plots, due to differences in phototrophic attraction of migrant forms. He found that sprayed leaves reflected more intense light and absorbed more of the longer wave lengths than did unsprayed leaves.

It appears from the above data that both copper and sulfur fungicides tend either to repel gravid females or to weaken the normal stimuli for oviposition (since unsprayed trees had the highest average numbers of eggs per leaf), but that the copper-containing treatments or at least Bordeaux mixture were the most effective in this respect. It seems from the conclusions of the authors cited above that theoretically these differences may be due to either chemical or physical properties of the respective residues which are perceived by the gravid females, or to a combination of both of these groups of factors. Since ovipositing moths show a marked perference for strongly vegetative trees it is quite evident that they are readily influenced by some attribute of such host plants, and it seems logical that this influence might be masked in different degrees by various chemical spray residues.

Conclusion.—The cherry case-bearer oviposits most readily on unsprayed cherry trees, less abundantly on those treated with sulfur fungicides, and least readily on Bordeaux-sprayed trees.

Cherry trees in good vegetative condition (fertilized with nitrogen, heavily pruned, and young) are more conducive to case-bearer oviposition than are "normal" checks.

Heavily infested leaves tend to turn yellow and fall while the young larvae are feeding—a reaction which often serves materially to reduce large case-bearer populations on cherries and certain varieties of apples.

Theoretically the effect of fungicidal spray residues in reducing case-bearer oviposition may be due to physical, chemical or combined physical and chemical properties.—1-10-36.

Literature Cited

(*1*) **Brues, C. T.** 1920. The selection of food plants by insects, with special reference to lepidopterous larvae. Am. Nat. **54**:313–32.

(*2*) **Granovsky, A. A.** 1930. Some insect pests of the cherry and apple orchards of Door county. Wis. Ag. Exp. Sta. Stencil Bul. **96.**

(*3*) **Moore, J. B.** 1935. Studies of reactions of potato aphids to sprayed and unsprayed potato leaves. Jour. Econ. Ent. **28**(2):436–42. 5 figs., bibliog. Apr.

(*4*) **Richardson, C. H.** 1925. The oviposition response of insects. U.S.D.A. Dept. Bul. **1324.**

STUDIES OF CERTAIN NEW WETTING AGENTS AND THEIR APPLICATION WITH INSECTICIDES AND FUNGICIDES[1]

RALPH E. HEAL, JOHN B. SCHMITT and JOSEPH M. GINSBURG, *New Jersey Agricultural Experiment Station, New Brunswick*

This paper presents results of studies with three closely related neutral wetting agents which proved compatible with hard water as well as with various contact insecticides, stomach poisons and fungicides. Chemically they are sodium salts of sulfonated diphenyl compounds, named *Aresket*, *Areskap* and *Aresklene*. The studies were started in the summer of 1934 by Dr. Joseph M. Ginsburg (*2*) and John B. Schmitt and are at present continued by Ralph E. Heal.

Each one of these three chemicals can be prepared in form of either dry powder, or solutions of various concentrations in water, alcohol, acetone and other organic solvents. They are manufactured by the Rubber Service Laboratories Company, a division of the Monsanto Chemical Company. The fact that they are soluble in both organic solvents and water makes it possible to incorporate them in extracts of derris and pyrethrum in suitable concentrations to produce good wetting and spreading on plants when made up to the desired dilutions with water for spraying against insects.

The main object of this investigation was to determine the practical application of these chemicals as spreading and wetting agents with insecticides and fungicides.

Methods and results.—The entire problem comprises the following investigations, each one of which represents a separate study.

LABORATORY EXPERIMENTS.—(1) Compatibility with hard water. (2) Wetting and spreading properties. (3) Plant injury. (4) Preparation of wettable sulfur. (5) Emulsification properties.

FIELD EXPERIMENTS.—(1) Spreading of nicotine–bentonite sprays. (2) Oil emulsions with lead arsenate. (3) Sulfur–lead arsenate sprays. (4) Control of red mite with derris and *Aresket*. (5) Control of apple aphids with derris or nicotine containing *Aresket*.

Laboratory experiments. COMPATIBILITY WITH HARD WATER.—The presence of hard water in certain localities often renders many excellent wetting agents, such as soap, sulfonated oils, etc., valueless for use with insecticides, due to the formation of insoluble precipitates with calcium, magnesium or iron present in the water. The three wetting agents were tested with artificial hard water prepared as described by Jones & Davidson (*4*). One liter of water contained .2 gm. $MgSO_4$, .5 gm. $CaCl_2$ and .25 gm. $NaHCO_3$. This formula gives a water of 71° hardness U. S. *Areskap*, *Aresket* and *Aresklene* diluted 1:200, 1:400, 1:800 and 1:1600 with this water gave satisfactory, although slightly turbid solutions, and

[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

did not cause any flocculation or precipitation after several hours standing. When sprayed on nasturtium leaves the wetting with these dilutions compared well with solutions of distilled water containing equivalent amounts of the wetting agents. Similar results were also obtained with a one per cent solution of $CaCl_2$, which gives a hardness of about 530° U. S. These tests have shown that all the three compounds are compatible with hard water.

Wetting and Spreading Properties.—One of the most important properties of a liquid contact insecticide is its ability thoroughly to wet the foliage and the insects. This depends not only upon the liquid itself but also upon the nature of the surfaces to be wet. Of course, there is considerable variation in wetting of leaves of the same kind, even from the same plant. In apple leaves, for instance, the upper surface is often more difficult to wet than the under surface, while with the chrysanthemum the under surfaces vary considerably. Laboratory and field tests were therefore made on 10 varieties of plants, using several leaves per test and repeating each test as many times as was necessary to secure reliable results. The laboratory tests were conducted as follows: leaves were dipped in solutions containing various concentrations of the wetting agents and momentarily removed. The completeness in coverage and the lasting uniformity of the liquid film on the leaf surfaces were carefully noted. In the field the entire plant was thoroughly sprayed, using several plants per test, and close observations were made. The following varieties of plants were employed for testing: cabbage, nasturtium, snapdragon, chrysanthemum, apple, bean, pepper, melon, tomato and eggplant.

The results have shown that waxy foliage, such as that of cabbage, pepper and nasturtium (which are very hard to wet) requires dilutions of 1:800 of either *Areskap* or *Aresket* and 1:1600 of *Aresklene* to produce satisfactory wetting as compared with 1:500 of coconut-oil soap. Leaves of lower interfacial tensions, such as apple, bean and chrysanthemum, can be thoroughly wetted with dilutions ranging from 1:1600 to 1:2000 of any of one of the three wetting agents.

Plant Injury.—It is obvious that before a wetting agent may be safely mixed with insecticides it is necessary first to ascertain whether it is injurious to plants. Accordingly, during the summer of 1934 the three products were tested on vegetable, greenhouse, orchard and ornamental plants. These tests were made by thoroughly spraying the plants with three different concentrations of the wetting agents, several plants being employed for each test, and examining them later for injury. Each of the three wetting agents was applied at dilutions of 1:200, 1:400 and 1:800. The spraying with the two higher dilutions was repeated approximately 10 days after the first spray application. The following 24 varieties were sprayed: pepper, strawberry, tomato, eggplant, bean, turnip, squash, beet, cabbage, chrysanthemum, carnation, dahlia, aster, salvia, phlox, cedar, spiraea, lilac, rose, arborvitae, white pine, snapdragon, apple and peach.

No injury resulted to any one of the plants at dilutions of 1:800 and 1:400. At dilutions of 1:200 injury appeared on rose with *Areskap;* on apple with all three products, and on peach with *Aresket.*

In August 1935, the three products were tested on vegetable and ornamental plants again to insure the tolerance of plants for these compounds. Each product was tested at concentrations of 1:400 and 1:200 on corn, tomato, cucumber, cabbage, pepper, bean and rose. Three successive applications of each spray were spaced at weekly to fortnightly intervals. No injury on any plant was noticed at any time.

From these results it appears that dilutions of 1:400 or higher are perfectly safe on foliage but injury may result to certain plants when the three chemicals are applied at higher concentrations. Since, however, dilutions of 1:1600 or even higher are sufficient to produce good wetting on most of the plants tested, a substantial margin of safety is present, eliminating any possible danger of foliage injury.

Preparation of Wettable Sulfur.—Due to the high interfacial tension existing between water and elemental sulfur it is difficult to mix the two together for spraying purposes, unless a third reagent is used which either acts as a surface tension reducer or converts the sulfur to colloidal or partially colloidal forms. Since each one of the three wetting agents possess low surface tension in aqueous solutions, tests were made to determine the minimum quantity of the chemicals required to incorporate with dry sulfur in order readily to disperse the latter in water.

Sulfur, 300-mesh fine, was mixed in mortar and pestle with small quantities of the spreader, and the resultant mixtures tested on water. By these tests it was found that 1 part of either *Aresket* or *Areskap* mixed with about 500 parts of sulfur gave a water-wettable sulfur. *Aresket* seemed to be more efficient in this respect than *Areskap*, giving fairly good results even with 1 part to 800 parts of sulfur, provided that the mixing was done very thoroughly. *Aresklene* (paste form) proved less efficient than either *Areskap* or *Aresket* in producing wettable sulfur.

Following these tests experiments were conducted with aqueous solutions of *Aresket* in order to ascertain whether sulfur would become wettable when merely sifted into it without previous intimate mixing.

Accordingly, solutions of *Aresket* of 1:1600 were prepared and the 300-mesh non-wettable sulfur added at the rate of 8 and 16 pounds to the 100 gallons. In each case the sulfur was rapidly submerged, even without stirring, and similar results were obtained with dilutions of 1:2000 and 1:3000. The practical limit was reached at dilutions of 1:4000 in which the sulfur was taken in slowly, requiring considerable agitation. Based on these results, it can be stated that 1 part of *Aresket* in 3000 parts of water is sufficient to make sulfur wettable applied at the rate of 16 pounds to 100 gallons. The results with *Areskap* and *Aresklene* were not as satisfactory as with *Aresket*.

These tests were repeated with complete spray mixtures containing 3 pounds lead arsenate, 4 pounds hydrated lime, 10 pounds sulfur per 100 gallons of water, and enough *Aresket* to give the desired concentration. At dilutions of 1:2000 of *Aresket* the sulfur became readily wettable, while at dilutions of 1:3000 the dispersion of the sulfur was at a considably lower rate, requiring some agitation.

These laboratory results justified field experiments on a large scale, and these were conducted during the summer of 1935.

EMULSIFICATION PROPERTIES.—Studies of the properties of the three compounds to emulsify oils or to make oils miscible revealed the following information. Stable emulsions of petroleum oils can be readily prepared with about .5 per cent of either *Aresklene* or *Areskap*. *Aresket* proved inferior to the other two products. Enough oil can be incorporated to produce emulsions containing from 66 to 70 per cent actual oil. The resultant emulsion is free flowing and is similar in its physical consistency to the well-known soap emulsion but differs from soap emulsions in that it is compatible with hard water, lime sulfur and lead arsenate. Furthermore, as is not the case with other organic emulsifiers, such as ammonium caseinate, gums, skim milk or blood albumin, no preservative is necessary to keep the stock emulsion in storage for long periods of time without decomposing. Emulsions of kerosene, *Diamond paraffin* (a light lubricating oil used for dormant spraying) and highly refined, white oils (used for summer spraying), prepared in the spring of 1934 and kept

Table 1.—Amounts of *Areskap* required to make liquid insecticides water miscible.

SOLVENT OR OIL	INSECTICIDE	*Areskap*, GM. PER 100 CC.
Pine Oil	None	20–25
Pine Oil	Derris or pyrethrum	20–25
Camphor–sassafrassy	Derris	10–20
Lethane	None	20–30
Super-Concentrate	Derris	15–20
O-dichlorobenzene	None	10–15

air tight, were still stable and seemed to be as good as freshly prepared when examined on December 16, 1935.

The formula found most suitable for preparing the emulsions consists of two-thirds oil and one-third water. The emulsifier is first dissolved in the water and the oil is gradually added to the aqueous solution with continuous pumping and stirring until the mixture becomes thick and homogeneous, showing no free oil on the surface. For home-made emulsions the ordinary spray tank, provided with agitators and pump capable of developing 250 or more pounds pressure, can be effectively employed. For commercial preparations a colloidal mill will probably be most suitable.

In the attempts to prepare water miscible oils it was found that *Areskap* and *Aresklene*, especially the former, possess these properties. This applies to oils in which *Areskap* is soluble, such as pine oil, tung oil, linseed, oleic acid and similar oils. It does not apply to petroleum and other oils in which *Areskap* is insoluble. The procedure in preparing miscible oils consists of dissolving various quantities of *Areskap* in the oil, using heat if necessary. The resultant mixture is clear and readily miscible with soft or hard water in all proportions, giving a permanent milky solution. *Areskap* was also found useful in making certain solvents, containing insecticides, water miscible, such as *Lethane;* camphor-sassafrassy containing derris extract; pine oil containing extracts of either pyrethrum or derris; *Super-Concentrate* containing derris extract, and o-dichlorobenzene. The proportions of *Areskap* required to make the above materials miscible are given in table 1. The *Areskap* thus

incorporated also endows the insecticide with wetting and spreading properties. If sprayed at high dilutions, such as 1:400 or 1:800, additional amounts of *Areskap*, above the quantity which makes the oil miscible, may be necessary. They may either be incorporated into the concentrated insecticide or added to the diluted spray, to obtain efficient wetting. This, of course, will depend on the kind of plant to which the spray is applied, as well as on the nature of the insecticide.

Field experiments. Spreading of Nicotine–Bentonite Sprays.—Driggers has reported (*1*) work of the 1935 season in which he compared *Aresket* with two other spreaders, skim milk and sulpho-ammonium soap, for use with a tank-mixed bentonite–nicotine combination for codling moth control. Basing his conclusions on observations of spraying procedure and of foliage condition throughout the year, and on codling moth injury counts accompanied by analyses of leaf samples for nicotine throughout the season, he concluded that *Aresket* at 2 ounces to 100 gallons, and skim milk at one-fourth pound to 100 gallons were equally satisfactory as spreaders in this spray. Both were better than the sulpho-ammonium soap. The *Aresket*, however, at the prevailing prices was more expensive than the skim milk.

Oil Emulsions with Lead Arsenate.—As mentioned earlier, laboratory tests showed that *Aresklene* and *Areskap* could be used to make stable oil emulsions. In order to test such emulsions in the field, two home-made emulsions, emulsified with *Areskap* and *Aresklene*, respectively, were included in the oils to be tested in a group of lead arsenate–oil blocks for codling moth control. This experiment was conducted in cooperation with Dr. B. F. Driggers.

Four blocks of 48 trees each, including three varieties, Rome, Stayman and Wealthy, in this orchard received similar treatments which included seven cover sprays for codling moth control. Four of these sprays were lead arsenate–oil combinations. The treatments of these blocks differed only in the type of oil emulsion used in the lead arsenate–oil sprays. In one block a commercial oil emulsion was used, while in the other three, home-made oil emulsions were used. All oil emulsions were used so as to give one-half per cent actual oil in the sprays. All the home-made emulsions were made with the same oil, *Sonneborn's Spray Stock B*, but three different emulsifying agents, *Areskap*, *Aresklene* and ammonium caseinate, were used. All the home-made oils consisted of 7 parts oil to 3 parts water. *Aresklene* and *Areskap* were used as emulsifying agents at the rate of .5 per cent by weight. Ammonium caseinate stock emulsion contained .17 per cent ammonium hydroxide (28 per cent ammonia) and .25 per cent casein. In this emulsion .17 per cent cresylic acid was incorporated in the oil to prevent decomposition.

The emulsions were made in a home-constructed apparatus which consists of an open-top drum with an agitator and a motor-driven gear pump. The gear pump has two inlets and one outlet. One inlet leads from the drum and the outlet feeds back to the drum. The other inlet feeds from a separate container.

The water containing the emulsifying agent was placed in the drum and circulated through the pump. The oil was added slowly through the

second inlet. When all the oil was added the emulsion was circulated through the pump several times and kept agitated in the drum.

Observations as to foliage injury showed no differentiation among the four treatments. Examination with reference to codling moth injury showed all oils to be equally effective in lead arsenate combination for codling moth control. The four blocks yielded 97, 99, 99 and 98 per cent clean fruit, respectively.

In these experiments it was shown that stable oil emulsions could be prepared from a summer orchard oil, using *Aresklene* or *Areskap* as emulsifying agents. These products have the advantages as emulsifying agents of not decomposing on standing and of compatability with other components of orchard sprays, as well as with hard water.

Sulfur–Lead Arsenate Sprays.—Laboratory tests showed that the three products, especially *Aresket*, could be used to make flowers of sulfur wettable. In order to determine the effectiveness of *Aresket* for this in the field, and also to study its use as a spreader for a lead arsenate spray, experimental blocks were set up in an apple orchard at Bridgeton, N. J. Three blocks of 100 trees each of the Golden Delicious variety were used.

The main part of the orchard was being sprayed by the grower with a spray consisting of lead arsenate 3 pounds, lime 10 pounds, and a so-called colloidal sulfur containing bentonite 10 pounds to 100 gallons, with 1 pint of fish-oil soap as a spreader. In the experimental blocks the colloidal sulfur was replaced by elemental sulfur at 10 pounds to 100 gallons. In preliminary tests *Aresket* was used at 1, 2, 3 and 5 ounces to 100 gallons. Analyses of leaf samples for arsenic showed that all concentrations except 1 ounce to 100 gallons gave excessive run-off of the spray and rendered the residue too susceptible to weathering. One ounce to 100 gallons appeared to be the minimum concentration that could be used to obtain good spreading. The orchard received four cover sprays for first-brood codling moth, but was not sprayed for second brood.

Continued experiments showed that the lead arsenate–lime–sulfur combination with *Aresket* at 1 ounce to 100 gallons was not retained well enough on the foliage through the weathering processes. The addition of colloidal clay (*Wyo-Jel*) to the combination at the rate of 5 pounds to 100 gallons, however, supplied the necessary adhesion.

Aresket at 1 ounce to 100 gallons wet the sulfur satisfactorily by the following procedure. The agitator in the spray tank was covered with water. *Aresket* was added, followed by the sulfur, while the agitator was in operation. Then the other materials were added while the tank was filled with water. The sulfur remained in suspension with agitation.

The lead arsenate–lime–sulfur–colloidal-clay combination with *Aresket* at 1 ounce to 100 gallons showed equally as well in arsenic retention and codling moth control as the lead arsenate–lime–colloidal sulfur–fish-oil soap combination with which the rest of the orchard was sprayed. In cost, the sulfur–*Aresket* combination was considerably lower than the colloidal sulfur–fish-oil soap combination. This indicated a very substantial reduction and, if experiments in scab control planned for the future prove it satisfactory for this purpose, the use of such a combination can be recommended as an economy.

Arsenic determinations on foliage samples were made available through the cooperation of H. C. McLean and A. L. Weber of the Spray Residue Investigation Department at the New Jersey Agricultural Experiment Station.

CONTROL OF RED MITE WITH DERRIS AND *Aresket*.—During the summer of 1935 a heavy infestation of European red mite was experienced in many of the apple orchards of New Jersey. This outbreak occurred at a time when the trees carried deposits of sulfur and lead arsenate on their foliage. The presence of the sulfur would not permit the use of an oil spray without injury.

Field experiments were carried out in which a water suspension of derris with neutral wetting agents was used for the control of this pest. Four neutral wetting agents, *Aresket*, *Areskap*, *Aresklene* and skim milk, were tested.

From these field tests it was determined that a spray consisting of 1.25 to 2 pounds of finely ground derris root of 4 per cent rotenone content, and 10 ounces of *Aresket* or *Areskap* to 100 gallons, was satisfactory for red mite control under the existing conditions. This spray, however, had no ovicidal effect, and so two applications were necessary. These were spaced at an interval sufficient to permit hatching of the eggs without any of the larvae reaching maturity. The sprays were compatible with the deposits on the foliage. *Aresklene* was as effective as the other compounds but was dropped from consideration because of higher cost. Skim milk was not satisfactory in this spray. These experiments were reported in full in a paper by Heal (*3*) at the Eastern Branch meetings at Baltimore.

CONTROL OF APPLE APHID WITH DERRIS OR NICOTINE CONTAINING *Aresket*.—Laboratory tests with green apple aphids and rosy apple aphids indicated that *Aresket* could be used as a wetting agent with derris or nicotine sprays for their control. Using derris as a water suspension of $1\frac{1}{3}$ pounds of root of 4 per cent rotenone content to 100 gallons, or nicotine at the rate of two-thirds of a pint of nicotine sulfate to 100 gallons, it was found that the minimum effective concentration of *Aresket* in these sprays was 1:1200, or 10 ounces to 100 gallons, for control of green apple aphids. Rosy apple aphids proved more difficult to wet and a higher concentration, 1:1000, or 12 ounces to 100 gallons, was necessary to give satisfactory kill.

Field tests which were carried out substantiated these observations. Control of both species of aphids was effected with both derris and nicotine at the above-mentioned rates when the *Aresket* was used at a concentration of 1:1000. When the concentration of the wetting agent was lower than this the same concentrations of toxic agents were not as effective against these insects.

The use of a neutral wetting agent in such a spray in place of the usual recommendation of soap is indicated to be valuable when spray residue on the foliage or other components of the spray are not compatible with soap.

A review of the field results shows clearly the distinction which must be made between the use of *Aresket* as a spreader for stomach-poison

sprays and its use as a wetting agent for contact-poison sprays. The results from its use in codling moth sprays show that a low concentration, such as 1 ounce to 100 gallons, is effective in spreading the spray on the foliage. Higher concentrations have a deleterious effect, causing excessive run-off and lack of adhesion to the foliage through the processes of weathering. In its use as a wetting agent in the contact sprays against apple aphids and red mite, low concentrations were ineffective, and a comparatively high concentration of 10 ounces to 100 gallons was required to wet the insects so that the contact poisons became effective.

The results of the above experiments have indicated some of the values of these products in the field of insect control. Further field work on these investigations is planned for the coming season.

Summary and conclusions.—Laboratory and field tests were carried out with three neutral wetting agents, *Aresket*, *Areskap* and *Aresklene* to determine their compatability with hard waters, their wetting and spreading properties, the tolerance of plants to their presence on the foliage, their ability to make sulfur wettable, their emulsification properties, their compatibility with lead arsenate, and their general effectiveness as spreaders with stomach poisons, contact insecticides and fungicides in various orchard spray combinations.

The results of these investigations have lead to the following conclusions:

All three products are compatible with hard water.

Plants are tolerant to all three products in dilutions of 1:400 or higher.

Aresket can be used effectively in making elemental sulfur wettable, either when mixed dry with the sulfur or when in water solution to which the sulfur is added.

Aresklene at the rate of one-half per cent will make stable petroleum-oil emulsions containing 66 to 70 per cent actual oil.

Areskap will render many oils and solvents in which it is soluble, miscible with water.

Aresket at 2 ounces to 100 gallons can be used satisfactorily as a spreader in a tank-mixed bentonite–nicotine spray for codling moth control.

Aresklene and *Areskap* at one-half per cent are suitable emulsifying agents for summer oils for use in lead arsenate—oil combinations for codling moth control.

Aresket at 1 ounce to 100 gallons will render flowers of sulfur wettable for use in orchard spraying. A procedure is indicated by which the sulfur is added to the tank before the spray is diluted to its final concentration. This concentration also gives efficient spreading for a sulfur–lime–lead arsenate combination but the presence of colloidal clay is required to give adhesion.

The use of a sulfur–colloidal clay–*Aresket* combination shows a reduction in cost over a commercial bentonite–sulfur spreader combination.

Aresket and *Areskap* at 10 ounces to 100 gallons are effective wetting agents with derris for European red mite control, and with derris or nicotine for apple aphid control. Their use is indicated in spray combinations not compatible with soap.—7-9-36.

LITERATURE CITED

(1) **Driggers, Byrley F.** 1936. Codling moth experiments in1935. JOUR. ECON. ENT. 29(2):369–78. Apr.

(2) **Ginsburg, J. M.** 1935. New wetting agents for old insecticides. JOUR. ECON. ENT. 28(1):224–8. Bibliog. Feb.

(3) **Heal, R. E.** 1936. Derris insecticides. VI. Summer control of European red mite on apple with derris and neutral wetting agents. JOUR. ECON. ENT. 29(3): 550–6. Bibliog. June.

(4) **Jones, H. A.** and W. A. Davidson. 1931. Preparations containing rotenone for use as insecticides. I. Aqueous suspensions. JOUR. ECON. ENT. 24(1):244–57. Feb.

MISCIBLE OIL EMULSIFIERS AND SPREADERS[1]

C. O. EDDY,[2] *Kentucky Agricultural Experiment Station, Lexington*

In practical and experimental work utilizing numerous mineral oils and other liquid insecticides in Kentucky, an emulsifier was needed that could be easily used with each of them. For several years such liquid emulsifiers have been made without heat and later easily mixed with oil, kerosene, carbon disulfide and orthodichlorobenzene without heating or pumping. The dilutions of the emulsions in water were very stable.

The emulsifiers have been used with mineral oil to make stable emulsions for dipping nursery stock as it was sold. These emulsifiers have been combined with mineral oil for use with Bordeaux mixture, which had previously been treated with sugar as a stabilizer, to form a combination scalecide and fungicide that lasted several months. Seven ounces of sugar were used with the 6:6:100 Bordeaux mixture, as it was found that lesser amounts failed to preserve the Bordeaux mixture and larger amounts broke it down, thus releasing water-soluble copper.

The same emulsifiers, used with carbon disulphide and orthodichlorobenzene for tests, showed that in addition to the ease of mixing, the resulting stable emulsions were more toxic to white grubs and similar insects than were the quick-breaking, or less stable, emulsions.

Emulsifiers have been used that were also spreaders for contact sprays.

Formula 729*

82.5% mineral oil
8.5% oleic acid
1.0% phenol
3.0% iso-amyl alcohol
1.5% ethylene glycol monoethyl ether†
3.5% KOH:H_2O–1:1

* All formulae are written in per cent by weight.
† *Cellosolve* is one commercial name for ethylene glycol monoethyl ether.

Some of the emulsifiers have been added to kerosene for use as flocculators and spreaders for lead arsenate.

In the first formula developed by trial, the emulsifier was made with the insecticide. This fact is illustrated in Formula 729. The ingredients were mixed in the order given. The resulting mixture was transparent and the diluted emulsion was stable. The amount of alkali used depended upon the

[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the director.
[2] Now with the Louisiana Agricultural Experiment Station, Baton Rouge.

saponification number of the oleic acid, the neutralization value of the phenol, and the acidity of the oil, and, therefore, was calculated mathematically since these values were all known or could be determined. Sufficient KOH solution was added to saponify or neutralize completely all the components. The correctness of the calculation was later checked by using chemical indicators which showed pH values of the dilutions.

The purpose of the phenol, iso-amyl alcohol and ethylene glycol monoethyl ether was twofold. First they made the potassium oleate (KOH + oleic acid) and mineral oil miscible and stable in stock mixture. Second, when the combination was mixed with water they stabilized the resulting emulsion and prevented hydrolysis, so that the relatively small amount of soap (potassium oleate) kept the oils in emulsion for long periods.

Carbon disulphide, or orthodichlorobenzene, or kerosene was substituted in Formula 729 for the mineral oil to make miscible mixtures with these insecticides. Cresol was used successfully in the place of phenol in part of the experimental work with each insecticide.

Because of the adaptability of Formula 729 for use with many different types of liquid insectitides it was possible to test their effectiveness easily, and without complications resulting from the use of different emulsifiers. It will be noted that the amount of oil is much higher and the amount of emulsifier much lower than in many other miscible-oil formulae. For instance, in U. S. Department of Agriculture Technical Bulletin 478, "The Use of Carbon Disulphide Against the Japanese Beetle," Flemming & Baker give numerous formulae for making miscible formulae of CS_2 where 30 per cent of the combination is emulsifier. In the text, "Insecticides, Fungicides, and Appliances," Anderson & Roth give a formula where the amount of emulsifier is 40 per cent. The method of making described by Anderson & Roth is also very complex when compared with the fact that no heat or complicated mixing processes are required in the formulae reported in this article.

It was found that all the materials in Formula 729 except the mineral oil could be combined to form a liquid stock emulsifier, as follows: oleic acid 48.6 per cent, phenol 5.7 per cent, iso-amyl alcohol 17.1 per cent, ethylene glycol monethyl ether 8.6 per cent, and KOH:H_2O–1:1, 20 per cent. There were several advantages in making the emulsifier before adding it to the insecticide. The minimum amount of emulsifier needed for different insecticides varied. Even the minimum amount of emulsifier required for different types of mineral oil was variable. When the emulsifier was made first the amount needed could be added gradually to the oil, or other insecticide, until the mixture diluted in water to form a stable emulsion.

Because of the poisonous nature (to animals) and disagreeable odor of the iso-amyl alcohol, it became necessary in some of the testing work to substitute other compounds for it. When amyl alcohol was substituted in Formula 729 the mixture was satisfactory, but when diluted with water the emulsion was somewhat less stable. A combination of compounds from pine distillates was also used in place of iso-amyl alcohol in some of the work, but special precautions were always observed. For

instance, when an oleic acid made by Werk and Company was used, 1½ per cent of alpha terpineol and 1½ per cent of yarmor pine oil were substituted for the iso-amyl alcohol. When an oleic acid made by the Beaver-Remmers-Graham Company was used, 2 per cent of alpha terpineol and 1 per cent of yarmor pine oil were used successfully in place of the alcohol. The saponification number of the oleic acid made by Werk and Company was about 25 points above that of the acid made by Beaver-Remmers-Graham Company.

A less complex emulsifier for miscible mixtures that has been in use for a shorter period is Formula C6. Less care and skill were required for preparing it after the best proportion of components in the formula had been determined by trial. Emulsion C6 was a clear amber solution. The components were added in the order listed. The mixture was stirred as each was added. About 15 per cent of emulsifier C6 was used with the insecticides to form a miscible mixture and a stable emulsion when diluted with water.

Formula C6

32.5% oleic acid
32.5% cresol (U.S.P. Koppers)
10.0% yarmor pine oil
15.0% KOH:H_2O–1:1
10.0% kerosene

100.0%

Phenol has not been successfully substituted for the cresol in this formula.

During the last year a number of formulae have been used for making emulsifiers that have also served as highly efficient spreaders for nicotine and other contact poisons. Formula E25-61 illustrated this combined spreader and emulsifier.

Formula E25–61

25.0% oleic acid (commercial with high saponification number)
10.0% yarmor pine oil
25.0% wood resin*
15.0% cresol (U.S.P. Koppers)
20.0% KOH:H_2O–1:1
5.0% kerosene

100.0%

* Grades of wood resin were I or N with saponification number 170.

Spreader-emulsifier E25-61 was a dark amber solution which flowed freely, although, judging from the formula, it would seem to be a solid because of the high soap (potassium oleate and potassium resinate) content. Because of these features this formula has exceptional value in that it has high emulsifying power and mixes readily with liquid insecticides. When 15 to 20 per cent of the mixture made according to Formula E25–61 was added to lubricating oil, kerosene, carbon disulphide, or orthodichlorobenzene, it made clear miscible emulsions that were very stable when diluted with water. This emulsifier is an efficient spreader for contact sprays. In tests, one part of it spread 2000 parts of nicotine solution on aphids on nasturtium leaves, resulting in a high killing efficiency of the nicotine.

In some instances, alpha terpineol was substituted for yarmor pine oil or for a portion of it, particularly when the emulsifier was used with kerosene.

Other materials were found useful in making the spreader-emulsifier combination. For instance, as a substitute for cresol, London resin oil

was especially effective in emulsifiers used with kerosene, and pine-tar oil (sp. gr. 1.035) in emulsifiers used with mineral oil. These materials were used in larger amounts than the cresol; *i.e.*, 25 to 30 per cent instead of 10 to 15 per cent. The oleic acid and resin were reduced proportionately and the amount of alkali adjusted accordingly.

In some of the emulsifiers, the pine oil or alpha terpineol, or a combination of them (usually 2 parts of alpha terpineol and 1 part of yarmor pine oil) was increased to equal or exceed the amount of resin, and the cresol was decreased to about 7 per cent. The resin and oleic acid remained unchanged. About 25 per cent of these spreader-emulsifiers was required for making miscible emulsions.

Wood resin was used in spreader-emulsifier E25-61 because it is a highly efficient spreader and emulsifier. Gum resin was found to be a good spreader when used in these combinations but it was not a good emulsifier. In comparing spreading efficiency of the materials used in the spreader-emulsifiers, it was found that the saponified wood resin was about three times as efficient a spreader for nicotine as the saponified plant or animal fats or fatty acids.

These emulsifiers contain a very small amount of inert material. For example, formula E25-61 contains only 10 per cent inert material as water. All the other ingredients have value as both spreaders and emulsifiers.

When products with different physical properties were used it was often necessary to modify or change the proportions of the formulae. For this reason manufacturers' names are given in the formulae when deemed necessary. In general, however, the combinations used have been successful with products from a number of sources.

In testing work, it has been noted that the resin, in formulae containing large amounts of it, reacted with copper and lime to form gummy compounds that caused trouble in certain types of high-pressure spray apparatus.—7-10-36.

A NEW FORM OF CRYOLITE

S. MARCOVITCH and W. W. STANLEY, *Tennessee Agricultural Experiment Station, Knoxville*

In spite of all attempts to develop a non-arsenical insecticide, the fluorine compounds, such as cryolite, are still, for many insects, the best substitutes available. Although they compare favorably with the arsenicals in toxicity toward insects, the fluorine compounds leave much to be desired in physical properties. Some of them are too heavy, do not remain well in suspension, and lack adhesiveness, while others are too reactive and inclined to injure foliage. In our efforts to obtain a more desirable material, an improved fluorine insecticide, apparently related to cryolite, was developed in cooperation with the research laboratories of the Aluminum Ore Company. The physical characteristics are greatly improved and in many respects are even superior to lead arsenate. This new product will be subsequently referred to as *Alorco* cryolite.

Physical and chemical properties.—*Alorco* cryolite is manufactured from fluorides, such as natural cryolite, aluminum fluoride, and fluorspar used in connection with the manufacture of aluminum. The exact composition and formula of *Alorco* are yet to be determined, but it seems to be a form of sodium fluoaluminate with properties suggestive of cryolite. By a special process of precipitation the material is produced in a very finely divided condition. It is bulky and occupies from 85 to 100 cubic inches to the pound. Many of the present fluorine compounds, such as natural cryolite, occupy only 40 cubic inches to the pound. In addition, *Alorco* cryolite is practically free from soluble sodium fluoride and contains ingredients that impart valuable sticking properties. The suspension properties are extremely good. Several tests indicated that a large proportion will remain in suspension for several hours, and even after 24 hours a considerable proportion of the material will be found to be suspended. In comparative tests *Alorco* settled out only 1 cc. in 90 minutes, while lead arsenate settled out 8 cc. and natural cryolite $8\frac{1}{2}$ cc. Aqueous solutions of this insecticide were slightly alkaline, indicating that it may not injure foliage and may be compatible with other insecticides.

Laboratory tests show that a dry-spray deposit of *Alorco* on glass resists removal by tap water much better than similar deposits of lead arsenate or cryolite. J. E. Morrow made the tests for adherence by producing an artificial rain storm. Seventy-three per cent of the *Alorco* adhered to the glass slides, while only 5 per cent was recorded for lead arsenate and 4 per cent for natural cryolite. *Alorco* is thus shown to have such good sticking properties that oils would not seem to be necessary to make them stick. This should greatly simplify the residue problem, since the oils used in conjunction with cryolite greatly interefere with the easy removal by acid. Laboratory tests showed also that *Alorco* was more easily removed from glass by 1 per cent HCl than was lead arsenate.

Effect on foliage.—Applied as a spray and as a dust to a number of plants, including apple, peach, potato, bean, cabbage, cucumber, cantaloupe, tobacco and smartweed, *Alorco* caused no foliage injury throughout the whole season. This is remarkable in view of the fact that hydrolysis proceeds readily when the material is diluted with large amounts of water. We were unable to get any foliage injury whatever on smartweed. In order to find out how much soluble sodium fluoride the plant could tolerate, we added 8 per cent to *Alorco* without causing visible foliage injury by this mixture. Tobacco dust with 8 per cent sodium fluoride caused no injury. However, talc, natural cryolite, or Jungman's synthetic cryolite with 8 per cent sodium fluoride caused appreciable burning.

Toxicity to insects.—Laboratory and greenhouse tests were made to get comparative values for *Alorco* and standard stomach poisons. Early in the spring, Colorado potato beetle larvae were available. Plants were sprayed at the rate of 2 pounds to 50 gallons of water. *Alorco*, synthetic and natural cryolite, and lead arsenate were equally effective, killing about 90 per cent of the larvae in 48 hours.

Dusting tests were also run on the sweet-potato flea beetle, *Chaetoc-*

nema confinis, in the greenhouse. Average percentage mortality at the end of 72 hours was as follows: natural cryolite 63, *Dutox* 54, calcium arsenate 53, *Alorco* 82, and check 12.

As flea beetles are difficult to poison and as *Dutox* has heretofore given good results against these insects, the results with *Alorco* indicate that we have an excellent flea beetle insecticide.

The Mexican bean beetle, *Epilachna corrupta*, appeared in the spring in moderate abundance, and field tests under practical conditions were instituted. Several commercial cryolites and a commercial derris powder (*Cubor*) were compared with *Alorco*, spraying them on June 6 and 14, 1935, and making counts after the second application.

The results in terms of the number of bean beetle larvae per row (1/240 acre) in each plot showed no larvae for *Alorco* where used at the rate of 3 pounds to 50 gallons of water, whereas natural cryolite left 118. At 2 pounds to 50 gallons *Cubor* left 10 insects and *Alorco* 34. *Alorco* thus gave definitely better results than natural cryolite and almost as good as *Cubor*. As Cubor is three to five times more costly than *Alorco*, the latter material is the more economical.

Dusts gave fairly good control, but on the whole were not as effective as the sprays.

The second generation of Mexican bean beetle appeared in large enough numbers for a dosage test. One pound of *Alorco* to 50 gallons left 691 larvae per row, 2 pounds left 295, and 3 pounds 214. The unsprayed beans had 2113 insects. Since the plots with 2 pounds to 50 gallons of water were well protected it seems that this dosage would be the most economical.

A commercial peach and apple orchard was sprayed with *Alorco*, and although the data obtained were not conclusive, the results indicated control on a par with lead arsenate.

Soapstone-HF compound.—Fluorine is a by-product in the manufacture of phosphates by various processes being developed by the Tennessee Valley Authority at Wilson dam.

The soapstone-HF compound is made by stirring up soapstone with the quantity of commercial HF necessary to combine with the Ca, Mg, Al, Fe, and SiO_2. The mixture is then washed with water and dried. Under these conditions the resulting mixture always contains approximately 48 per cent fluorine; 1.86 per cent free HF also being present.

The approximate composition of the material is as follows:

MgF_2	43 %
AlF_3	15.2%
FeF_3	17.1%
CaF_2	3.4%

In tests on the Mexican bean beetle it compared favorably with the standard insecticides, such as magnesium arsenate and cryolite.

Summary.—A new form of sodium fluoaluminate represents a vast improvement over present fluorine insecticides in physical properties. The new insecticide is bulky, occupies 85 to 100 cubic inches to the pound, and possesses excellent suspension properties. Sprays and dusts

on apple, peach, potato, beans, cucumber, tobacco and smartweed showed no foliage injury whatever. Tests against the sweet-potato flea beetle showed excellent results as compared with *Dutox* and calcium arsenate. Field experiments against the Mexican bean beetle showed control practically as good as *Cubor* and better than *Dutox*, magnesium arsenate and cryolite. A soapstone-HF compound appears promising as a new fluorine insecticide.—6-27-36.

RELATION OF SOIL UTILIZATION TO WIREWORM INJURY

JOHN H. HAWKINS, *Maine Agricultural Experiment Station, Orono*

There are certain types of soil found in Maine which are seldom if ever inhabited by wireworms in excessive numbers. Other types of soil are heavily populated whenever conditions suitable for the incidence and growth of wireworms prevail. The present investigation shows that the densest populations of wireworms occur in soil of a heavy clay type, usually dark in color, and that these insects are often relatively scarce or entirely absent in soil of light clay loam. Between these extremes are soils neither very heavy nor very light in nature, which are inhabited by wireworms in moderate to small numbers. Most of the injurious wireworms found in Maine prefer relatively moist soil for their habitation, and light clay soils are usually better drained and dry out more quickly than the heavy clay types. The general principle pertaining to the kind of soil in relation to the numbers of wireworms present applies to the following: the wheat wireworm, *Agriotes mancus* Say, wireworms of the genera *Melanotus* and *Ludius*, the larvae of *Hemicrepidius decoloratus* Say, and to a lesser extent to those of *Cryptohypnus abbreviatus* Say.

Some farmers are so well acquainted with their soil that they can tell without examination what areas on the farm are relatively free from wireworms. This is usually not the case, however, and whenever there is doubt concerning their presence or numbers it is better to secure this information previous to planting.

Taking the wireworm census.—Taking of the wireworm census includes the removal of representative samples of the soil and counting the wireworms which are included. For experimental purposes random sampling over an area large enough to represent distribution of the population has proven a satisfactory method. Wireworms present are usually unevenly distributed even within a small area of soil. Consequently the number of samples necessary for significant results cannot be accurately arrived at in advance of the sampling. A larger number of samples is required for obtaining experimental data than is necessary for such practical information as is needed by farmers in estimating the safety of crops in relation to the number of wireworms present. The superiority of a large number of small samples over a small number of large samples as a true representation of the number and distribution of wireworms is indicated by careful comparisons. The only argument for

the smaller size samples seems to be that it is possible to take a larger number of them within a given time. Since considerable time is required to take a very large number of soil samples, we have lately used areas 1 foot square almost exclusively. Regardless of the size of samples taken, the soil should always be removed to such a depth as is necessary to obtain all the wireworms present. For species common in Maine this depth seldom exceeds 8 inches.

Table 1 represents data obtained from an experimental plot of approximately two acres. Numbers in the table represent the number of wireworms found in each soil sample and the arrangement of the numbers represents the approximate distribution of the samples in the plot.

Table 1.—Wireworm population of a two-acre plot.

WIREWORMS SIFTED FROM INDIVIDUAL SOIL SAMPLES

3		0		1		0		1		2		1		4		2			
	0		0		0		0		0		1		1		1		5		
2		0		3		3		0		7		1		1		4			
	0		1		0		5		0		1		1		4		0		
4		4		1		1		1		6		2		0		6			
	4		4		6		5		3		3		3		1		2		
3		4		2		2		1		0		1		3		1			
	15		3		11		9		5		1		1		5		10		
3		2		0		1		2		2		0		1		2			

The method of taking samples for estimating the number of wireworms as a basis for practical application of data concerning population density in relation to crop injury is to take soil samples first from selected areas. In case of those species of wireworms common in Maine, low-lying, flat or poorly drained areas are first sampled If wireworms are found in these samples, then other areas are sampled progressively from the most favorable wireworm habitations toward those least favorable. If wireworms are found only in very small numbers in the most favorable portions of the field, few if any samples need be taken from the areas less favorable for the wireworms.

Apparatus employed for removing wireworms from soil samples are various. We have found that hand sifting is suitable for small areas or where only a few samples are to be taken. For larger areas a rotary sifter is more efficient. This apparatus is a regular ash sifter of a type often used in New England, consisting principally of a hopper and a cylinder with quarter-inch mesh, which is turned by means of a crank. For the sake of convenience the sifter is placed on a wooden frame. The soil is poured into the hopper and passes into the rotating cylinder. The wireworms are screened out and fall on a dark piece of canvas which is placed below. Boxes are also sometimes placed below the sifter to receive the soil and wireworms. The frame holds the cylinder at a height convenient for seeing the wireworms as they drop through the screen.

Safety limits of crops in regard to wireworm populations.—When the approximate population of a given soil area is known, it is possible to place crops so that only a minimum amount of injury will be caused by wireworms, providing the safety limits of crops are known. The safety limit of any crop in regard to wireworm population is the number of

wireworms per unit area beyond which excessive injury is likely to occur.

In studying the safety limits of crops, plots were laid out and data on the number of wireworms in the plots were obtained. Crops of different kinds were then planted and observed for injury by the wireworms of various populations. Check plots where wireworms were eliminated before planting were maintained in some cases to test the theory that migration might be a factor. In all cases where crops were grown in the check plots, migration was so slight that the effect was negligible. There was a slight amount of migration, however, from check plots kept fallow by cultivation toward other plots where crops were growing. Otherwise the wireworm population was practically stationary from spring until August, when pupation occurred. During this period there is the natural increase in wireworms due to oviposition and hatching of the young

Table 2.—Wireworm populations and safety limits of crops.

Crop	Wireworms per Acre
Potatoes	14,000
Corn in hills	125,000
Corn drilled closely in rows (ensilage corn)	150,000
Oats	200,000
Wheat	200,000
Beans	300,000
Peas	300,000
Timothy and redtop	400,000
Buckwheat	Very resistant, seed only affected
Clovers	Practically immune

larvae in soil where conditions favorable to these phenomena are maintained. This does not alter the wireworm population as affecting safety limits, however, for newly hatched wireworms are not a factor in the injury of the crops during the first season.

Table 2 shows the safety limits of some of the more important field crops grown in Maine. These figures are based on experimental data obtained from plots conducted annually since 1927 and are borne out by observations of conditions on farms of several localities in Maine.

The foregoing table shows that potatoes are susceptible to injury by a relatively small number of wireworms. This is in spite of the fact that other crops are preferred as food. The apparent contradiction is explained on the basis that it is the mature or nearly mature tubers, the marketable product, that is injured. Moreover, the tubers are present in the soil at a time of year when wireworms feed heavily in preparation for hibernation and when comparatively few other succulent plants are available for food.

Wireworm injury in relation to density of plant population.—There is an interesting relationship between the number of plants per unit area and the amount of injury caused by a given number of wireworms. Data at hand indicate that host resistance often depends upon the number of plants per unit area being sufficient to furnish food for the wireworms present without enough injury being done materially to lower the crop yield as a whole. Where grain or grass crops are broadcast or drilled

in closely adjacent rows the number of plants within a given area is so great that the injury or destruction of a few plants is not noticeable. For the same reason, excess seed can sometimes be used advantageously for hill or row crops as well as for grass or grain. Where wireworms are present in some numbers in grain or grassland and no injury is noticeable, an apparent outbreak may occur when the land is plowed up and planted to some crop with relatively fewer plants per given area. Consequently what appear to be outbreaks are sometimes not outbreaks at all but only concentration of attack.

Obtaining maximum utilization of the soil.—It is more important now than ever that wireworm injuries be kept at a minimum in the potato growing sections of the state. This is because of the potato-branding law which excludes from grade U.S. No. 1 all potatoes showing 5 per cent waste because of wireworms or other insect injuries or which have their appearance materially damaged thereby. The use of the best potato soil, such as Caribou loam, or other light loam soils, enables the growers to avoid unnecessary injury to their potato crops. In order to utilize such soil to the greatest advantage for the main crop, potatoes, soil specialists in Maine are advocating that a green-manure crop be grown whenever it is necessary to good soil practices. Where the soil is in a good state of fertility a green-manure crop grown once in three years should be often enough. Such a practice is also good from the standpoint of wireworm control for there are two cultivated crops in three years, and if necessary the soil can be cultivated well into June during the year when the green-manure crop is planted. Thus the wireworms are reduced in number by pupation each year and the cultural practices make conditions unsuitable for increase in their numbers through hatching of new generations.

Conclusion.—Experimental data indicate that the common field crops grown in Maine are affected least when they are grown where the wireworm population is consistent with the safety of the crop planted. Fortunately this practice, in addition to its value for keeping injuries done to crops by wireworms at a minimum, usually adjusts the crop to a soil type well adapted to its growth.—6-25-36.

STUDIES ON CUCUMBER BEETLE CONTROL IN 1935

GEORGE E. GOULD, *Purdue University Agricultural Experiment Station, Lafayette, Ind.*

The poor results obtained from the recommended control measures against the cucumber beetle make additional study of this problem desirable. The usual recommendation of a 1:19 calcium arsenate–gypsum dust has given only partial success, especially in seasons when beetles are abundant. Although much loss is caused by the direct destruction of the plants by the beetles, the more important damage is the spreading of the wilt organism through the fields. Since this disease will develop after the feeding by any infective beetle, it follows then that these insects must be eliminated from the field before they become widespread and

prevalent. The effective control measure must either kill the beetles at their first feeding on the plants or else it must check the wilt disease.

Beetle control tests.—Experiments during the past season were a continuation of previous work on this problem. The plot technic, however, was greatly modified and followed the small-plot arrangement used by Dietz & Zeisert[1] in 1934. In addition, the effect of certain insecticides on plant growth was studied in another series of plots.

The season was favorable for the experiments as the beetles were exceedingly abundant at all times and rainfall was frequent and distributed uniformly throughout the growing period. The test plots were located on a fertile field which had a uniform slope to the west. Cucumber seed of the variety Longfellow was planted on June 15 in hills 8 feet apart and in rows 10 feet apart. Each plot consisted of five hills replicated five times in a restricted randomized arrangement. Hard, washing rains, occurring as these plants were coming up and again later, made it necessary to replant twice to obtain a uniform stand. The first plants came through the ground on June 20 and on the same day the striped cucumber beetles appeared. Spotted cucumber beetles were found early in July and became rather abundant late in the month.

Eleven different materials and an untreated check were included in this experiment. The mixtures and dilutions were as follows: calcium arsenate and gypsum at 1:9 and 1:19 dilutions as the standard treatments; zinc arsenate and gypsum at 1:9; barium fluosilicate and cryolite, both diluted 1:4 with clay; a ready-mixed derris dust containing three-fourths per cent active ingredients; a 2:2:50 Bordeaux spray with 2 pounds of calcium arsenate added to compare with a 2:3:50 calcium arsenate–copper oxychloride spray; a nicotine–copper–lime dust; and two different arsenates used with copper oxychloride in a dust at a 1:1:3 dilution with clay.

The first applications were made June 23, when plants were up in practically all hills. In dusting, a uniform coating of the mixtures was applied over the plants and especially around their bases. Spraying was done with a knapsack sprayer and a thorough coating was applied on both sides of the leaves. Records were kept of the quantity of dusts used at each application. Frequent hard rains and the abundance of beetles made it necessary to repeat applications often and even then the plants were on four occasions unprotected for two days or longer. A total of 12 applications was applied on the following dates: June 23 and 27, July 1, 3, 4, 5, 9, 13, 17, 24, 27 and 30.

It was noticed from the first that at least two materials, barium fluosilicate and the nicotine–copper–lime dust, produced a definite retrading of plant growth. The barium fluosilicate mixture killed over half of the small plants but appeared not to harm those that survived the first applications. The Bordeaux-sprayed plants had a browning of the leaf edges, although growth was not noticeably checked.

Plants were thinned twice to a total of four per hill and a record was kept of the length of the plants removed. Of course, these plants were the smaller ones, but the average length, as recorded in the table, shows

[1] 1935. Jour. Econ. Ent. 28(2):310–14. Apr.

Table 1.—Results of various insecticide and fungicide mixtures on cucumbers.

Treatment*	Total Weight of Materials, Ounces	Average Length of Vines Thinned, Inches	Per Cent of Wilt	No. Beetles Dead or Alive After 8th Application	Yield, No. of Fruits	Yield, Pounds of Fruit	Yield, Bushels per Acre	Cost of Materials per Acre
A. Calcium arsenate (2), copper oxychloride (3) water (50)	26†	9	3.6	8 dead 32 alive	1615	792	1147	$8.64‡
B. Calcium arsenate (1), copper oxychloride (1), clay (3)	166	7.8	6	2 dead 4 alive	1533	752	1096	34.64‡
C. Manganese arsenate (1), copper oxychloride (1), clay (3)	185	8.3	5.3	4 dead 11 alive	1442	709	1024	38.59‡
D. Calcium arsenate (2), copper sulfate (2), hydrated lime (2), water (50)	32†	8.5	4	5 dead 14 alive	1365	650	886	7.20
E. Derris dust (1 per cent rotenone)	124	8.2	15.5	23 dead 33 alive	1199	565	820	88.88
F. Calcium arsenate (1), Gypsum (9)	224	9.3	24	23 dead 26 alive	1182	556	806	21.33
G. Nicotine sulfate 40 per cent (1), monohydrated copper sulfate (5), hydrated lime (14)	131	6.7	11	3 dead 14 alive	1121	518	748	65.20
H. Cryolite (1), clay (4)	127	6.7	25	12 dead 62 alive	1090	509	740	25.39
I. Zinc arsenate (1), gypsum (9)	214	6.8	14.4	3 dead 35 alive	1021	474	690	18.45
J. Calcium arsenate (1), gypsum (19)	207	6.9	15	22 dead 32 alive	912	400	581	14.30
K. Barium fluosilicate (1), clay (4)	61	2	6.2	2 dead 2 alive	612	281	407	12.19
L. Check (no treatment)		5.6	30	3 dead 225 alive	642	273	390	

* Copper oxychloride (containing 16 per cent metallic copper), barium fluosilicate and manganese arsenate furnished by the Grasselli Chemical Co., natural cryolite by the Kalo Co., zinc arsenate and zinc arsenite by the General Chemical Co., and derris dust by the S. B. Penick & Co.

† Estimated quantity.

‡ Copper oxychloride is still in the experimental stage and the cost is based on a price of 8 cents a pound.

a significant difference between certain treatments. Throughout the season the plots with copper treatments appeared to be more vigorous and in September were green for about two weeks longer. Residue of the two copper sprays was still noticeable on some of the older leaves at the end of the experiment.

In the final thinning on July 22, four plants per hill or a possible total of 100 plants per treatment were left. On the barium fluosilicate plots, this total number was 81 plants. The first count of death from wilt was made July 31. At that time 11 plants in the check plots had been destroyed by the feeding of beetles. A record of wilt was made at each picking and the total for the season is given in table 1.

It is impossible to determine the relative efficiency of the various treatments by a count of dead and live beetles on the plots because these insects are so active and migrate from plot to plot and field to field. However, observations made at the time of each pick showed that beetles were constantly present in the field. A count of dead and live beetles was made after the eighth application, at which time the leaves and soil about the hills were carefully examined. This count, as shown in table 1, indicates that beetles preferred certain plots. No conclusion can be drawn from the number of dead beetles, as these may have migrated from adjoining plots or death may be caused from parasitism by the tachinid fly *Chaetophleps setosa* Coq. Collections of beetles that were made weekly starting July 30 showed a parasitism decreasing from 25 to 6 per cent in early September.

The first harvest from the plots was made on August 2 and the final pick, September 17. The variety of cucumber used in this experiment was a large type and was not ready for picking until the fruits were at least 6 inches long. All plots were picked three times a week except in early September when cold, wet weather checked the growth. The production of fruit from the barium fluosilicate plots was retarded and the initial harvest was about two weeks later than that of the others.

From the information summarized in the table, it is seen that a number of criteria may be considered in drawing conclusions as to the most efficient material. The copper oxychloride–calcium arsenate spray undoubtedly gave the best results, followed close by the Bordeaux–calcium arsenate spray and the two copper oxychloride–arsenical dusts. In the final analysis, however, it is the total yield from the plots and the cost of the treatment that furnish the figures for comparison by both the commercial grower and the experimenter. The grower is interested in obtaining the maximum yield at the lowest cost, while to the entomologist yield reflects a variety of factors, such as vine growth, wilt control and insect control.

Using the yield weight as the unit, the data were analyzed according to the methods of Wishart[2] to determine their significance. It is not necessary to describe the details of this method here, but the analysis of variance due to the treatment and to plot location shows that the differences from both of these factors are highly significant (odds of over 99

[2] 1931. The technique of field experiments. Rothamstead Conferences 13:13–21. Rothamstead Experiment Station, Harpenden, Hertfordshire, England.

to 1). The data were analyzed further to determine the differences between any two treatments necessary to be significant. It was found that a difference of 195 pounds between any two plot totals would happen only once in 100 trials through chance alone (a difference of 135 pounds between any two plot totals shows a significance of 22 to 1).

The cost item often determines whether or not the grower uses any method of control. A glance at the yield figures shows that the increased yields in all plots, except the one treated with barium fluosilicate, would more than pay for the extra expense involved. The cost of the derris dust and the nicotine–copper–lime dust is excessive and might in certain seasons exceed any increase resulting from the application of either. The cost of materials used in the sprays was considerably cheaper, although the cost of application would be somewhat higher.

Plant tolerance tests.—In a second series of plots intended only to determine plant injury, 12 materials were applied four times to three replications of 20 hills each. Beetles were abundant in one end of this field and destroyed many of the hills after rains had washed the poisons from the plants. When the first blossoms appeared, all plants were cut off at the ground and the length of each was measured. Plants in five plots showed a significant increase over the remaining seven treatments and the check. The best material was a 1:9 calcium arsenate–gypsum dust, followed closely by a 1:1:3 calcium arsenate–sulfur–clay dust, a barium carbonate spray, a 1:4 zinc arsenate–clay dust and a 1:1 calcium arsenate–clay dust. Both 1:1 and 1:4 dilutions of zinc arsenite–clay dust caused severe burning and destroyed practically all plants. Hydrated lime used alone reduced the plant size and afforded little protection from beetles and wilt, for only 24 out of 60 hills had plants left in them when the results were taken.

Summary.—In a season of frequent rains and an abundance of cucumber beetles, which necessitated repeated applications of control methods, certain mixtures containing copper fungicides in addition to an arsenical showed decided promise for both beetle and cucurbit wilt control. While the cost of materials in sprays was considerably less than dusts, a copper oxychloride–calcium arsenical mixture in both dust and spray forms gave significant increases in yield over the standard 1:9 calcium arsenate–gypsum dust and check plots. Treatments containing barium fluosilicate, zinc arsenite, hydrated lime and copper–lime dust had definite injurious effect upon the cucumber plants.—6-25-36.

RÔLE OF LIGHT TRAPS IN CONTROL OF MUSHROOM SPRINGTAIL

C. C. COMPTON, *Illinois State Natural History Survey, Urbana*

The mushroom springtail, *Achorutes armatus* Nic., has long been known to be a troublesome pest of mushrooms. Its habit of feeding on the spawn piece, developing mycelium and fruiting bodies frequently results in heavy losses through greatly reduced yields of marketable

mushrooms. This tiny insect, scarcely 1.5 mm. in length when full grown, often becomes extremely abundant in mushroom beds. Population studies made in commercial mushroom houses have shown that it is not uncommon to find in excess of 200,000 individuals per cubic foot of compost. Populations exceeding 400,000 individuals per cubic foot of compost have been observed. Such heavy infestations are most likely to occur in the bottom beds where the compost fails to heat properly during the

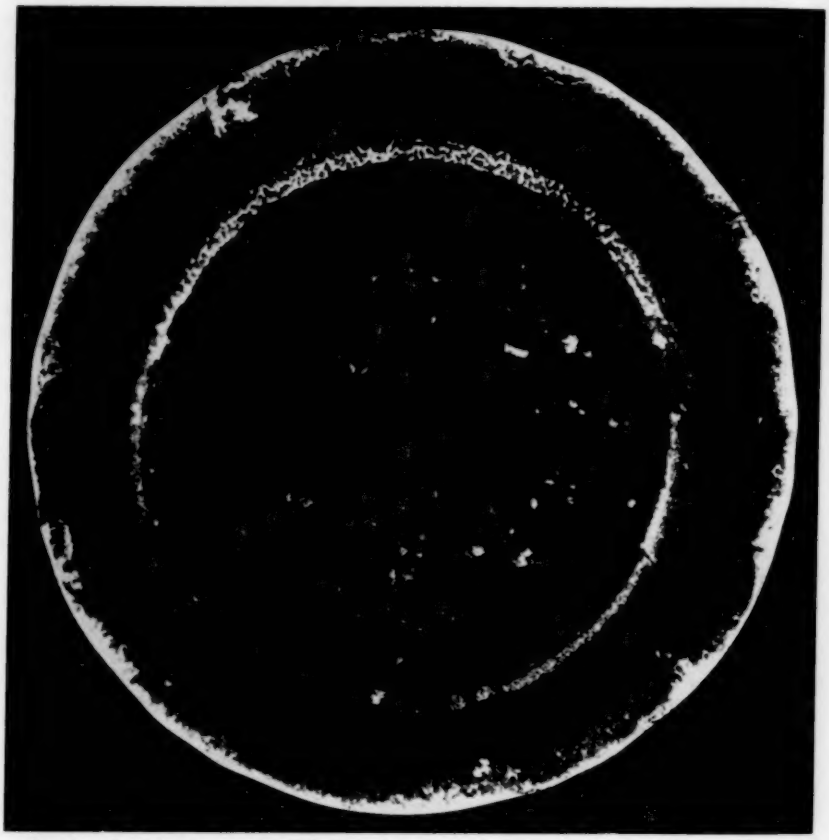

Fig. 1.—A 10-inch porcelain dinner plate showing more than 15 million springtails, trapped in six hours. Larger insects on the plate are house flies and staphylinids.

heating and sweating of the house. Trouble is most likely to be serious where the beds are built directly on the floor. Springtails in these bottom beds, unless brought under control, will migrate to higher beds following peak heat and may infest the entire house. Occasional scattered beds in the mushroom house may harbor heavy populations of springtails because of improper heating.

During the period of peak heat the springtails are driven from the beds

by the heating of the compost. The temperature of the beds except for those near the floor, may reach a temperature of 130° F or higher. The top beds naturally heat first and as the temperature rises the springtails are driven towards the floor. The temperature of the floor rarely rises above 100° F. Even where fans are used to aid in raising the temperature of the lower beds, there are spots on the floor where countless numbers of springtails may survive.

The methods we are recommending following peak heat for the control of mushroom mites are effective for the control of springtails (*1*). It is where composting is carelessly handled, the beds fail to heat properly, or springtails survive fumigation at peak heat that this insect is troublesome and other means of control must be employed.

Two-hundred-watt light traps effective.—Our investigations have shown that this springtail may be successfully trapped. The trap consists of a 10-inch white dinner plate pressed into the compost until it is about flush with the surface. Over the plate a 100 or 200-watt electric light is suspended so that the lower part of the bulb is about 8 inches above the plate. A small quantity of kerosene is placed in the plate to kill the springtails. *Achorutes armatus* exhibits a strong phototropic response, as has been noted by Thomas (*3*), and will travel toward the light rapidly. Hundred-watt bulbs of clear or frosted glass have been found very satisfactory, but 200-watt bulbs are slightly more attractive to the springtails. The best results are obtained where the traps are placed about 25 feet apart, although very satisfactory results have been obtained with 200-watt lights with traps placed 50 feet apart.

By substituting an electric coil radiating the same amount of heat for the light bulbs it has been found that the springtails do not show a positive thermotropic response. Their chemotropic response has been noted by Thomas (*2*). The springtails exhibit a positive chemotropic response to odors produced by kerosene, paradichlorobenzene and naphthalene. Where such materials are substituted for the light in the trap many springtails are attracted to the plate although these materials are very toxic to them. Under comparable conditions less than 1 per cent as many springtails is attracted to the plate through chemotropic responses as is attracted through their phototropic response. Figure 1 shows a plate after six hours under a 100-watt light on a bed of 30 square feet area. This plate contains more than 15 million springtails.

Springtail infestations should be located preferably before the beds are spawned or before the casing soil is applied. This may be accomplished by holding a 100-watt electric light over a white card lying flat on the surface of the compost. It has not been found necessary to uncover the spawn pieces as suggested by Thomas. If springtails are abundant an ordinary 3 by 5-inch card will show several hundred springtails after a one-minute exposure to the light. Where an electric light is not available a flashlight may be used, although the number of springtails attracted to the card will be somewhat less.

Insect response guides times and duration of trapping.—For maximum results the traps should be placed in operation five to seven days after the house has been through the heating process. The traps should

remain in operation four to 10 hours or as long as the springtails continue to come into the plate in numbers. Since springtails in the first and second instars are not greatly attracted by the light, the operation should be repeated after 10 to 14 days. This is seldom necessary except in the bottom beds. If the surface of the compost is dry it should be sprinkled lightly just before the traps are set, for the hygroscopic response of this insect is well known. During the period following spawning a temperature around 70° F is maintained in the beds and houses. Under these conditions the springtails are very active. After the spawn has made its growth, the temperature is allowed to drop to 50° to 60° F. During the production period the temperature is not favorable for springtail development, although springtails continue active at much lower temperatures than are conducive to the growing of mushrooms.

Like other known methods, light traps will not give 100 per cent control once the beds are infested but will reduce the springtail populations to a point where they are not of economic importance. Where the traps have been used before the casing soil was applied we have had excellent results in commercial houses during the last three years.—1-22-36.

Literature Cited

(*1*) **Compton, C. C.** 1935. Factors relating to the control of the mushroom mite, *Histiostoma gracilipes* Banks. Jour. Econ. Ent. **28**(2):465–8. Apr.
(*2*) **Thomas, C. A.** 1931. Mushroom insects. Pa. State Ag. Exp. Sta. Bul. **270**. Oct.
(*3*) ———— 1934. Further observations on mushroom insects. Jour. Econ. Ent. **27**(1):200–8. Feb.

LABORATORY STUDIES ON TOXICITY OF NICOTINE AND SOAP TO GLADIOLUS THRIPS AND ONION THRIPS

TAENIOTHRIPS SIMPLEX (MORISON), *THRIPS TABACI* LINDEMAN

H. D. Tate and Floyd Andre, *Iowa State College, Ames*[1]

Thysanoptera are recognized as important pests of many cultivated plants. Scarcely any species of plant is immune to their attacks and quite frequently their depredations result in serious commercial damage to various cultivated crops. Control of these insects has resolved itself largely into the problem of applying contact insecticides either in the form of dusts or sprays with perhaps a mixture of nicotine and soap playing the leading rôle as the toxic agent. Pyrethrum and derris compounds (*2*), however, have become increasingly important within recent years. Certain arsenicals, too, such as Paris green, manganese arsenate and the like, have been used, especially in the control of the gladiolus thrips, *Taeniothrips simplex* (Morison) (*1*).

It is a common practice among insecticide manufacturers, as well as entomologists, to make general recommendations for the control of

[1] Journal paper J-320 of the Iowa Agricultural Experiment Station, Ames. Project 135.

thrips by means of contact insecticides without paying particular attention to the species concerned. The possibility of the existence of a wide variation in susceptibility of different species seems not to have received adequate consideration, a condition which is perhaps partially due to the fact that only a very limited amount of precise toxicological information has been recorded with reference to this group of insects.

The present problem was instigated with two thoughts in mind: (1) to determine the toxicity of nicotine and soap to certain species of thrips under controlled laboratory conditions, and (2) to find if any variation in the susceptibility of different species existed.

Methods.—The method used in determining the relative toxicity of the spray materials was a modification of that described by Tattersfield

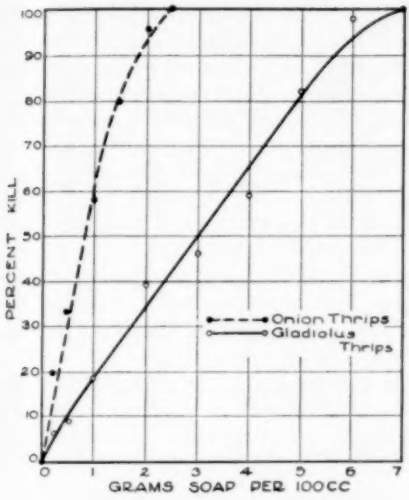

Fig. 1.—Curves showing toxicity of sodium oleate to the onion thrips and the gladiolus thrips.

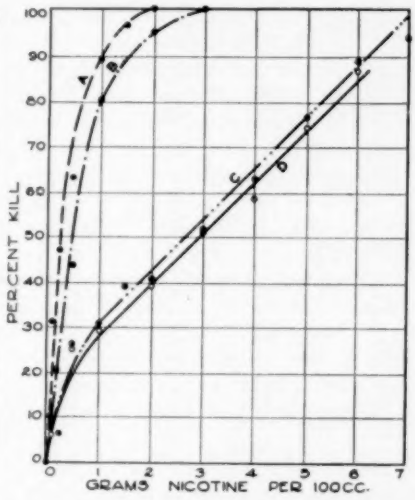

Fig. 2.—Curve A, toxicity to onion thrips of nicotine plus .25 per cent soap; curve B, toxicity of nicotine. Curve C, toxicity to gladiolus thrips of nicotine plus .25 per cent soap; curve D, toxicity of nicotine.

& Morris (*3*) in which groups of thrips were uniformly sprayed in a glass enclosure. The two species of thrips used in these studies, namely, the onion thrips, *Thrips tabaci* Lindeman, and the gladiolus thrips, *Taeniothrips simplex* (Morison), were chosen partly because of their importance as crop pests in Iowa and partly because they were available in large numbers.

The spray materials were made up in the form of aqueous solutions of nicotine alone and aqueous solutions containing nicotine and .25 per cent[2] of sodium oleate which served as a spreading agent. The relative toxicity of .25 per cent sodium oleate was checked at frequent intervals during the course of the experiment. The preparations were applied

[2] Per cent always signifies grams per 100 cc. of solution.

through a small atomizer nozzle at such a rate as to deliver on a dish containing the insects .52 gram of spray solution in 20 seconds. This value was also checked at frequent intervals during the course of the investigation to ascertain that it remained uniform. The thrips were sprayed in groups of 10 placed on a white cloth in a clean petri dish approximately 3 inches in diameter. Twenty-five replications were made for each concentration of spray material used.

Immediately after the thrips were sprayed they were transferred by means of a small camel's-hair brush to a fresh onion leaf in the case of *T. tabaci*, or on a portion of gladiolus corm in the case of *T. simplex*. The onion leaves were cut in lengths of about 1½ inches and both ends were sealed with a mixture of warmed paraffin and beeswax to prevent the

Table 1.—Percentage of thrips dead when sprayed with various concentrations of nicotine.

Nicotine				Nicotine plus Soap			
			Thrips tabaci				
Concentration grams per 100 cc.	No. Dead	Per Cent Dead	Control $\frac{(x-y)\ 100}{x}$	Concentration grams per 100 cc.	No. Dead	Per Cent Dead	Control $\frac{(x-y)\ 100}{x}$
3	250	100	100	2	250	100	100
2	239	95.6	95.3	1.5	243	97.2	97
1	205	82	80.8	1	226	90.4	89.7
.5	118	47.2	43.8	.5	167	66.8	63.5
.2	63	25.3	20.5	.25	126	50.4	47.2
.1	34	13.6	10.2	.1	84	33.6	31.4
Check, water	15	6	0	Check, water	15	6	0
			Taeniothrips simplex				
6	220	88	87.2	7	237	94.8	94.5
5	190	76	74.4	6	225	90	89.5
4	154	61.2	58.6	5	195	78	76.7
3	135	54	51	4	163	65.2	63.2
2	107	42.8	39.1	3	136	54.4	51.9
1	84	33.6	29.3	2	110	44	40.9
.5	75	30	25.5	1.5	106	42.2	39.1
.1	30	12	6.3	1	86	34.4	30.8
Check, water	15	6	0	.5	76	30.4	26.5
				.25	28	11.2	6.3
				Check, water	13	5.2	0

drying out of the plant tissues. With both species the portion of the plant on which they were placed after being sprayed was set in stender dishes which were covered with ground glass tops to prevent the escape of the thrips. After a 24-hour interval the number of dead and live insects was recorded.

Control groups were sprayed with water. The percentage of mortality of these varied only slightly in the different experiments throughout the investigation. However, the actual percentage of mortality is not shown on the curves but rather the net percentage, which was obtained by the formula $\frac{(x-y)\ 100}{x}$ where x is the per cent of live insects in the control group, and y the per cent alive in the experimental group.

Discussion.—By reference to figs. 1 and 2 it is obvious that there is a marked difference in susceptibility of the two species of thrips, *Thrips tabaci* and *Taeniothrips simplex*, to the compounds used. Of the two, *T. simplex* is in every instance killed less readily than *T. tabaci*. This holds true when either soap or nicotine was used alone or when the latter was mixed with .25 per cent soap. In the case of the onion thrips, *T. tabaci*,

a 50 per cent mortality resulted with approximately .30 per cent nicotine plus soap, whereas it took approximately 2.6 per cent nicotine plus soap to kill 50 per cent of the population of the gladiolus thrips. When sodium oleate was used alone an .8 per cent concentration killed 50 per cent of the *T. tabaci* population whereas it required a 2.8 per cent concentration to produce the same percentage of kill in the case of *T. simplex*.

A 7 per cent concentration of nicotine plus soap was required to kill 98 per cent of the population of *simplex*, whereas a 97 per cent mortality of *tabaci* resulted when only a 1.5 per cent concentration of nicotine plus soap was used.

In the accompanying table it may be noted that the mortality of the onion thrips used as controls was 6 per cent in both cases, whereas when this species was sprayed with .25 per cent sodium oleate, the mortality was 20 per cent. However, in the case of the gladiolus thrips the total mortality in the controls varied from 5.2 to 6 per cent, and a .25 per cent solution of sodium oleate killed only 6 per cent, which is not significantly different from the controls. The mortality resulting from spraying these two species with various other concentrations of soap are shown in fig. 1.

It is also quite evident that the addition of .25 per cent sodium oleate to nicotine markedly increases its toxicity to the onion thrips, a condition which did not exist in the case of the gladiolus thrips.

Summary.—Two species of thrips, namely *Thrips tabaci* Lindeman, the onion thrips, and *Taeniothrips simplex* (Morison), the gladiolus thrips, were used as experimental insects in determining the toxic effects of both nicotine and soap (sodium oleate) when used as sprays under laboratory conditions.

The gladiolus thrips proved to be far more resistant to the sprays in every instance. A 1.5 per cent solution of nicotine mixed with soap was slightly less toxic to the onion thrips than was a 7 per cent concentration of the same material to the gladiolus thrips.

A 50 per cent mortality of the gladiolus thrips resulted when a 3 per cent concentration of nicotine plus soap was used and the same kill was obtained with a .30 per cent concentration of the same spray in the case of the onion thrips. An .8 per cent concentration of sodium oleate killed 50 per cent of the population of *T. tabaci* whereas it required a 2.8 per cent concentration of this compound to produce the same mortality in the case of *T. simplex*.

From the data obtained it is quite evident that wide differences in susceptibility to contact insecticides exist between these two species, and recommendations for control of different species belonging to this order should be made with regard to the specific species at hand.—7-10-36.

Literature Cited

(1) **Dustan, A. G.** 1932. Recommendation for the control of the gladiolus thrips in 1932. Can. Dept. Ag., D.F.C. & G.I. 102, Ottawa No. 35. Mimeo. circ.

(2) **Richardson, H. H.** 1934. Studies on derris, nicotine, Paris green and other poisons in combination with molasses in the control of the gladiolus thrips. Jour. Ag. Res. **49**(4):359–73.

(3) **Tattersfield, F.** and H. M. Morris. 1924. An apparatus for testing the toxic values of contact insecticides under controlled conditions. Bul. Ent. Res. **14**:223.

TOXICITY OF KEROSENE STEEPATES OF DERRIS AND PYRETHRUM TO SOME POTATO INSECTS[1]

T. C. ALLEN, *University of Wisconsin, Madison*

During the progress of testing atomized oil sprays for the control of certain truck crop insects Allen (*1*), a comparative study was made of the relative toxicity of various contact insecticides to a number of insects. In the field, considerable diversity in the toxic values of insecticidal materials was noted among different species. Such variation in toxicity was particularly observed where pyrethrum and derris were used against the potato leafhopper, *Empoasca fabae* Harr., and the potato flea beetle, *Epitrix cucumeris* Harr. This suggested a definite specificity between insecticide and insect and comparative tests were consequently made with steepates of pyrethrum and derris.

Materials and methods.—Oil steepates of derris root containing five per cent rotenone, and pyrethrum flowers[2] were prepared by adding the ground ingredients to a highly refined kerosene-base oil.[3] The powdered materials were added to oil at the rate of 2 gms. per 100 cc., agitated, and allowed to stand for a period of 24 hours at room temperature. The oil was then filtered off and the filtrate was tested against the insects under laboratory conditions. No marked increase in toxicity followed the addition of larger quantities of derris or pyrethrum to the oil.

The method used for testing the insecticides was similar to that developed by Campbell & Sullivan (*2*) for testing kerosene-base insecticides against house flies. Insects were subjected to a settling mist of insecticide within a glass cylinder. In the present work with leafhoppers and flea beetles however, a slight variation was made in the equipment and in the procedure employed for testing these insects. The differences were essentially in the type of screen cage constructed for confining and subjecting the insects to the kerosene mist, and in the method of using these same cages in recording results Zermuehlen & Allen (*3*).

Insects for testing purposes were collected in the field from heavily infested potato foliage. Both potato leafhoppers and potato flea beetles were transferred into a single cage for testing. In this manner detailed observations of the relative toxicity of the insecticide to the leafhopper and to the flea beetle could be readily made in each cage. Nymphal forms were not included in these tests.

Prior to subjecting insects to the mist, 3 cc. of the insecticide were atomized into a large bell jar. The mist was atomized from the top of the jar at 12 pounds pressure. Ten seconds after the liquid had been atomized from the nozzle, the cage containing insects was inserted into the bell jar from below for a period of 30 seconds. The settling mist was decidedly more toxic to insects subjected at longer exposure periods.

Results.—The relative toxicity of derris and pyrethrum steepates to

[1] Published with the permission of the Director of the Wisconsin Agricultural Experiment Station.
[2] Samples obtained from John Powell & Co., Inc.
[3] Saybott viscosity 30 seconds, 100° F.

leafhoppers and flea beetles was recorded at one-half-hour, four-hour, and at 24-hour intervals. Considerable numbers of beetles were knocked down immediately following the applications of pyrethrum sprays. All these beetles recovered however, before the one-half-hour tabulation was made and consequently these results do not appear in table 1. It is evident that pyrethrum is quite specific in its toxicity as a contact insecticide to leafhoppers while derris is specific to flea beetles. Although the petroleum oil may be considered a more desirable solvent for pyrethrum and therefore may possess a greater toxic charge than similar steepates of derris, it is apparent that derris was very toxic to the potato flea beetle, a more heavily chitinized insect.

Table 1.—Relative toxicity of kerosene steepates of derris and pyrethrum to the potato leafhopper and the potato flea beetle following a 30-second exposure period to a settling mist.

Steepate	No. Insects	No. Tests	Number Down			Per Cent Kill in 24 Hrs.
			One-half Hr.	4 Hrs.	24 Hrs.	
			Leafhopper			
Derris	186	10	20	36	42	22.5
Pyrethrum	260	18	172	186	226	86.9
Check	180	14	6	8	16	8.8
			Flea Beetle			
Derris	160	10	118	128	132	82.5
Pyrethrum	80	8	3	4	4	5
Check	56	6	0	0	0	

Applications of atomized kerosene under field conditions.—Results of tests with straight kerosene oils containing 3 gallons of 20:1 basic pyrethrum extract to 97 gallons of kerosene have previously shown that the potato leafhopper can be controlled by this type of spray. A small garden tractor was employed the past season for applying these sprays in the field. Considerable difficulty however, has been met in obtaining a heavy concentration of mist about the plants and the use of a hood has been important in obtaining results.

At present, so far as it is known, these atomized oil sprays have no fungicidal value. This is desirable in Wisconsin for the control of certain potato diseases. The incorporation of various oil-soluble and oil-insoluble fungicidal salts into this type of spray is possible and is at present considered.—7-3-36.

Literature Cited

(1) **Allen, T. C.** 1935. Applications of atomized oil sprays to certain truck crop insects. Jour. Econ. Ent. **28**(2):496. Apr.

(2) **Campbell, F. L.** and W. N. Sullivan. 1934. A rapid laboratory method for testing kerosene-base insecticides against house flies. U.S.D.A., Bur. Ent. & Plant Quar., Div. Insect Physiol. and Toxicol. Mimeo. Et-11. Apr.

(3) **Zermuehlen, A. E.** and T. C. Allen. 1936. Modified procedure in testing petroleum base insecticides by the settling mist method. Soap **12**(6):105–7.

The peach mosaic disease is the subject of prohibitive quarantines recently issued by California, Colorado and Oregon.

HEAT TREATMENTS FOR CONTROL OF BULB MITE ON TUBEROSE

C. A. Weigel and R. H. Nelson, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

The bulb mite, *Rhizoglyphus hyacinthi* Bdv., is a common pest of tuberose, *Polianthes tuberosa* L. It attacks the dormant bulbs, especially when they are incompletely cured or dried, a condition that results from incorrect handling at the time of harvest or from improper storage. The mites usually enter the neck of the bulb and later are found in all parts of the bulb in association with decayed tissue. If no control measures are undertaken, the bulbs eventually break down and are a complete loss. Tuberoses are also attacked by the root-knot nematode, *Heterodera marioni* (Cornu), which likewise causes complete destruction of infested stocks.

In the past few years both these pests have increased in importance because certain states and foreign countries refuse entry of infested tuberose bulbs. There is therefore an urgent need for developing an effective treatment so that growers may be able, not only to cleanse their planting stock, but also to comply with the inspection and certification requirements of such states and countries as demand mite and nematode-free stock.

These studies were made possible by the cooperation of Dr. R. W. Leiby, entomologist of the North Carolina Department of Agriculture, and through the aid rendered by his assistants, J. A. Harris and D. L. Wray, as well as by John F. Croom, a commercial grower of tuberoses in Magnolia, N. C. Since much of the commercial production of tuberoses in the United States is centered around Magnolia, N. C., the field tests were conducted there.

The tests on the control of the root-knot nematode were made in cooperation with the Division of Nematology, Bureau of Plant Industry, U. S. Department of Agriculture, under the direction of Dr. G. Steiner, and have been published.[1] Briefly, the results indicate that complete mortality follows the hot-water treatment at 116° F for one hour, or 118° F or above for one-half hour, and the vapor-heat treatments at 122° F for one-half hour.

Two phases of the problem were studied: (1) the effectiveness of hot-water and vapor heat as a means of controlling the bulb mite, and (2) the tolerance of the dormant bulbs to these treatments.

Method of treatment.—The hot-water treatments were made in a portable, electrically heated, thermostatically controlled hot-water tank. Small lots of tubers were placed in cheesecloth sacks while being treated. In the 1935 tolerance tests the bulbs were placed in standard-bushel apple baskets, each holding about 1000 bulbs. The baskets permitted good circulation of the water during the treatment and drained quickly when removed from the tank.

[1] Sherman, G. W. 1935. The control of the root-knot nematode, *Heterodera marioni* (Cornu) (Anguillulinidae), on tuberoses by hot-water and vapor heat. Helminth Soc. Wash. Proc. 2(2):111. July.

The vapor-heat treatments were made in a standard vapor-heat room of the type that was originally developed for treating citrus fruits during the Mediterranean fruit fly campaign in Florida, and is now being used for treating narcissus in the control of the bulb flies, *Merodon equestris* Fab. and *Eumerus* sp., and the bulb or stem nematode, *Anguillulina dipsaci* (Kühn.).

Control tests.—The control tests were made with small lots (five bulbs per lot) of dormant tuberose bulbs known to be infested with the mites, at the temperatures and for the periods shown in table 1. After treatment each bulb was carefully examined under a wide-field binocular, and the mites were counted and their condition recorded as living or dead. The bulbs were then placed in tight paper sacks and left at room temperature

Table 1.—Effect of heat treatments on the bulb mite on tuberose, Washington' D. C., 1934.

Temperature °F	Minutes of Treatment	No. Mites Counted	Per Cent Mortality	Post-Treatment Hatching
		Hot-water Treatment		
110*	60	164	100	None hatched
112	60	33	100	None hatched
114	60	76	100	None hatched
116	60	102	100	None hatched
120	30	51	100	None hatched
122	30	110	100	None hatched
		Vapor-heat Treatment		
110	60	53	66	Eggs hatched
112	60	38	100	Eggs hatched
114	60	69	100	No eggs hatched
116	60	44	100	No eggs hatched
118	30	41	100	Eggs hatched
120	30	104	100	No eggs hatched
Check†		106	10.37	Eggs hatched

* Two lots of five bulbs each were tested at this temperature.
† Check for both treatments.

for two or three weeks, at the end of which time they were reexamined for evidence of post-treatment hatching.

The results, as shown in table 1, indicate that hot-water treatment, even at the lowest temperature tested, *i.e.*, 110° F, and for 60 minutes, was completely effective against all stages of this mite. Vapor heat, however, at 110° F for 60 minutes, was not completely effective against either the egg or the post-egg stages, and at 112° F post-treatment hatching occurred. There was also some hatching following the treatment at 118° F for 30 minutes. The lowest temperature completely effective was 114° F for 60 minutes.

Tolerance tests, 1934.—In 1934 two series of tolerance tests were run, one at Arlington Farm, Rosslyn, Va., and the other under commercial conditions at Magnolia, N. C. Flowering size No. 2 bulbs, apparently free of mites and nematodes, were used in these tests.

In both series treatments were made at temperatures from 110° to 124° F in steps of 2 degrees. The duration of some of the hot-water treatments was one-half hour and of the others one hour, and that of the

vapor-heat treatments was one hour. Replicate plantings were not made in either series, but all the bulbs of each lot were planted in a single plot.

In the Arlington Farm series 12 bulbs were used for each of these treatments and for each of two check lots. The bulbs were treated on April 27 and planted on May 9. The plants began blooming in June, but most of the flowering occurred during August, with a few straggling

Table 2.–Tolerance of tuberose bulbs to hot-water and vapor-heat treatments, Arlington Farm, Rosslyn, Va., 1934.

Temperature °F	Kind of Treatment	Hours of Treatment	No. Plants	Flowers Cut	Date First Spike in Bloom	Date 50 Per Cent in Bloom	Average Length of Flower Spikes, Inches
110	Hot water	½	11	10	June 25	Aug. 29	31.8
	Hot water	1	12	10	July 9	Aug. 29	30.7
	Vapor heat	1	12	11	July 9	Aug. 27	30
112	Hot water	½	12	13	Aug. 2	Aug. 29	30.4
	Hot water	1	12	8	Aug. 7	Aug. 24	32.6
	Vapor heat	1	12	11	July 9	Aug. 24	31.9
	Check*		12	13	Aug. 4	Aug. 22	28.2
114	Hot water	½	11	7	Aug. 24	Aug. 31	27.1
	Hot water	1	12	7	Aug. 20	Aug. 24	32.1
	Vapor heat	1	12	6	Aug. 2	Aug. 29	28.5
116	Hot water	½	12	11	Aug. 13	Sept. 5	25.6
	Hot water	1	11	6	Aug. 20	Aug. 24	30
	Vapor heat	1	12	6	July 9	Aug. 22	32
118	Hot water	½	12	7	July 9	Aug. 24	26.1
	Hot water	1	12	5	Aug. 24	Sept. 7	30.4
	Vapor heat	1	12	9	Aug. 22	Aug. 27	29.8
120	Hot water	½	12	6	July 24	Aug. 29	26
	Hot water	1	12	6	Aug. 22	Sept. 7	30.8
	Vapor heat	1	12	8	Aug. 20	Sept. 7	29.8
122	Hot water	½	12	8	Aug. 27	Aug. 31	27
	Hot water	1	12	5	Aug. 22	Aug. 24	30.8
	Vapor heat	1	12	7	July 24	Aug. 24	26.7
124	Hot water	½	12	11	Aug. 2	Aug. 31	26.6
	Hot water	1	12	7	Aug. 7	Aug. 24	29.1
	Vapor heat	1	12	7	Aug. 16	Aug. 29	30.7
	Check		12	9	Aug. 20	Aug. 27	26.7

* The bulbs treated at 110° and 112° F were from a source other than for those treated at the higher temperatures, and therefore must be compared with a different check.

spikes appearing until frost. All plants appeared to make about equal growth except one row, located next to a clover patch, which was somewhat retarded, probably from lack of moisture. The flowering data for this series are presented in table 2.

There is a rather wide range in date of appearance of the first flowers in the various plots, but the dates on which 50 per cent of the spikes were in bloom agree fairly well, as do the average heights of the spikes. Such differences in the data as are apparent do not seem to be correlated with the treatments, indicating that, from the standpoint of flowering, the dormant bulbs are not adversely affected by any of the treatments tried.

The series planted at Magnolia, N. C., consisted of 40 bulbs for each of the treatments previously mentioned and for each of three check lots.

The treatments were made May 23 and 24 and the tubers planted June 5.

A good stand of tuberoses (95–100 per cent) was obtained in all plots. and the foliage growth of the treated bulbs was equal to that of the checks. The results of this series of tests are shown in table 3.

The number of flower spikes varies considerably in the different plots. The variations, however, do not appear to be correlated with the treatments. Furthermore, the number of flower spikes was about the same in all the treated plots as in the checks. These results appear to be in agreement with those previously given for the Arlington Farm series, indicating that the treatments employed have no adverse effect upon the flowering of the plants.

Table 3.—Tolerance of tuberose bulbs to hot-water and vapor-heat treatments, Magnolia, N. C., 1934.

Temperature °F	Kind of Treatment	Hours of Treatment	No. Plants	No. Spikes	Average Unit Weight of Bulbs			
					Planted	Harvested	Increase	
					grams	*grams*	*grams*	*per cent*
110	Hot water	½	40	26	15.4	73	57.6	374
	Hot water	1	40	21	13.1	69.4	56.3	429.8
	Vapor heat	1	38	24	11.2	85.8	74.6	666.1
112	Hot water	½	39	24	14.4	92.3	77.9	540.9
	Hot water	1	39	25	13.7	68.3	54.6	398.5
	Vapor heat	1	38	21	12.6	67.1	54.5	432.5
114	Hot water	½	38	18	12.5	86.5	74	592
	Hot water	1	40	30	15.2	91.4	76.2	501.3
	Vapor heat	1	40	23	12.9	74.4	61.5	476.7
116	Hot water	½	39	30	12.5	77.1	64.6	516.8
	Hot water	1	39	26	11.9	84.3	72.4	608.4
	Vapor heat	1	40	25	13.2	101.3	88.1	667.4
118	Hot water	½	39	12	11.9	72.7	60.8	510.9
	Hot water	1	39	16	12.9	72.7	59.8	463.6
	Vapor heat	1	39	23	12.6	50.9	38.3	303.9
120	Hot water	½	40	21	12.6	79.4	66.8	530.2
	Hot water	1	39	19	10.6	75.6	65	613.2
	Vapor heat	1	40	13	12.5	55.3	42.8	342.4
122	Hot water	½	40	21	15.6	72.3	56.7	363.5
	Hot water	1	39	13	12.1	82.9	70.8	585.1
	Vapor heat	1	40	15	12.9	56.7	43.8	339.5
124	Hot water	½	39	10	13.7	101.8	88.1	643.1
	Hot water	1	40	12	11.2	97.8	86.6	773.2
	Vapor heat	1	40	24	12.5	95.7	83.2	665.6
	Checks		40	20	13.9	38.2	24.3	174.8
			40	13	12.5	41.1	28.6	228.8
			38	23	13.7	52.2	38.5	281

The percentage increase in unit weight of the harvested bulbs over that of the planting stock also varies greatly between the different lots. The relatively small increase in the check plots may be due in part to the fact that their growth was interfered with by an adjoining row of sweet potatoes, which may have deprived the tuberoses of moisture. The weight increases seem further to emphasize the tolerance of this plant to heat treatment of the dormant bulb.

Tolerance tests, 1935.—Another series of tolerance tests was made at Magnolia, N. C., on May 8 and 9, 1935, to obtain information on the practicability of applying the hot-water treatment under commercial

conditions, especially on the so-called "seed" bulbs (small offsets) or planting-stock size. Accordingly, bulbs of this size were used instead of the No. 2 flowering bulbs that were employed in the preceding year's tests. As has been mentioned, the bulbs were placed in wooden bushel baskets, each holding about 1000 bulbs. Treatments were made with hot water at 110° F for one hour, at 118° F for one-half hour, and at 120° F for one-half hour. The first treatment is the one which results of the 1934 tests indicated to be effective against the bulb mite alone, and the other two against the root-knot nematode or against a combined infestation of the two pests.

No large-scale tests were made with the vapor-heat treatment in the 1935 series, because no equipment was available.

The bulbs used were from two sources, designated as A and B. Those of source A, of which there were about 35,000, were well cured and in good condition. Those of source B, approximately 8000, had been improperly stored (banked in sand for the winter) so that the outer scales were badly decayed and had a considerable infestation of mites.

The bulbs from source A received the following treatments: 4000 bulbs were treated at a temperature of 110° F for one hour, 1800 bulbs were treated at 118° F for one-half hour, 10,000 bulbs were treated at 120° F for one-half hour and 3000 were left untreated as checks. From source B 2000 bulbs were given a treatment of 110° F for one hour and 6000 bulbs were treated at 118° F for one-half hour.

At the time of treatment a sample of 1000 bulbs from source A was selected from each of the treated lots and another sample of 1000 bulbs from the checks. In this way it was possible to have at harvest time a definite means of comparing the increase and the size of the bulbs produced from the various treatments with those produced from the checks. These bulbs were planted in the same field plots as the other bulbs given the same respective treatments. In order to avoid the influence of soil heterogeneity, each sample of 1000 bulbs was divided into four replicate lots of 250 bulbs each, and one lot of treated bulbs together with one lot of checks was planted in each of four different sections of the plot.

The bulbs from source A that were treated at 118° F for one-half hour were divided and planted on two different types of soil: (1) on land that had previously been in cultivation and upon a portion of which tuberoses had been grown, and (2) upon newly cleared land. The bulbs treated at 110° and 120° F were planted only on the newly cleared land. The purpose of such planting was to determine whether stock treated prior to planting and set out in newly cleared land would remain freer from infestation by mites and nematodes for a longer period than stock planted in soil in which tuberoses had been grown for a number of years. It is the usual practice, whenever possible, to plant the choicest stock in newly cleared land, because a better yield is often produced with apparently less mite and nematode infestation.

The bulbs from source B were planted on another farm upon newly cleared land. The grower, however, did not follow planting instructions and mixed the lots, making it impossible to obtain reliable data.

The data on these tolerance tests are not yet complete, for the final

observations will be taken after the crop is harvested. The following general observations, however, have thus far been made on the season's growth: The bulbs of both lots planted on the newly cleared land have shown equally good growth for all the treated lots and the checks. On the land that had been previously planted to tuberoses a very poor growth of both treated and check lots resulted. By contrast, in the remainder of the field, which had been previously in cultivation but planted to other crops, the bulbs of the treated lots produced a much better growth than the checks.

These results support the contention of growers that it is not desirable to grow tuberose in successive years on the same land. In general, however, the tests appear to be showing, as did those of last year, that the hot-water treatments are not detrimental to the dormant bulbs, and furthermore, that they are practical under commercial conditions.

Summary.—Small-scale tests during 1934 have shown that treating tuberose bulbs in hot water at 110° F for one hour, or with vapor heat at 114° F for one hour, is completely effective against all stages of the bulb mite.

The treatments that were found to be effective against the root-knot nematode—hot water at 116° F for one hour, 118° F or above for one-half hour, and vapor heat at 122° F for one-half hour—are therefore also effective against the bulb mite.

Tolerance tests with both types of treatments at the temperatures and durations herein indicated have shown that the dormant bulbs of either the flowering size or planting stock are not adversely affected, and that application of treatments on a commercial scale is practical.—7-6-36.

SURVEY OF INSECT FAUNA OF SOME MICHIGAN TROUT STREAMS

IN CONNECTION WITH IMPROVED AND UNIMPROVED STREAMS[1]

W. F. Morofsky, *Michigan State College, East Lansing*

The Michigan Emergency Conservation Work, in cooperation with the Department of Conservation and the Entomology Department of the Michigan State College, during 1935 conducted a survey of the insect fauna of selected improved and unimproved streams. Previous studies made during 1933 and 1934 on the stomach content of several hundred trout taken from their natural habitats and also bottom samples from seven important trout streams, gave definite knowledge of the natural foods constituting the diet of our Michigan trout. Many other factors may enter in and be determining factors, such as temperature, H-ion concentration, beaver dams, and many others, but the natural foods present are considered of basic importance by authorities studying fish life.

[1] Journal article 249 (n.s.) from the Michigan Agricultural Experiment Station.

Table 1.—Characteristics of Michigan streams studied.

Name and No. Stations	No. Samples	Average Width, Feet	Average Depth, Inches	Current	Banks	Bottom Types	Types of Obstructions
North Branch of Boardman river, 12	5	15	14	Slow	Brushy	Shifting sand, clay	Unimproved, very little cover. Improved, deflectors, barriers and covers.
Klacking creek, 12	4	9	12	Fast	Fairly open	Gravel, clay	Unimproved, stone and logs. Improved, deflectors and covers.
Houghton creek, 12	4	20	Upstream shallow, downstream deep	Fast	High clay, brushy	Sand-gravel, clay	Unimproved, many logs and boards. Improved, deflector and covers.
Hunt creek, 12	1	9	20	Medium	Brushy	Gravel, sand, mucky	Unimproved, poor. Improved, reflectorr barriers and covers
Canada creek, 12	4	20	18	Fast	Fairly brushy	Gravel, sand	Unimproved, fair. Improved, deflectors and covers being installed.
Cannon creek, 6	5	20	20	Fast	Open to brushy	Gravel, sand	No improvements but many logs and stone present ideal unimproved stream.
Maple river, 12	4	21	21	Medium to slow	Brushy	Sand, muck, gravel	Unimproved, poor, many beaver dams. Improved, deflectors and covers.
Little Manistee river, 12	5	22	16	Medium	Brushy to open	Gravel to sandy	Unimproved, logs and brush. Improved, deflectors and covers.
Manistee river, 6	5	80	36	Fast	High sand, some wooded area	Course gravel, sand	No improvements, many large boulders and logs.
East Branch of Fox creek, 12	1	24	18	Fast	Sand, some brush	Upstream gravel and mucky, sand below	Unimproved, good cover. Improved, deflectors and covers in shifting sand area, poor.
Two-hearted river, 12	1	60	26	Fast	Brushy	Solid stone to gravel	No improvements; large stones and shelters, cover good.
Little Two-hearted river, 12	1	30	28	Medium to fast	High banks, some wooded	Sandy muck and gravel	No improvements, many logs, conditions good.
South branch of Au Sable river, 6	1	40	29	Fast	High, open to brushy	Gravel to sandy	No improvements. Sample taken after large log jam had been removed.

Stream improvement is still in the experimental stages and the effects and results will not be determined for many years but its intended purpose is to provide shelter and cover for fish, to prevent soil erosion along banks, to regulate stream flow, etc. Primarily, then, stream improvement is meant to increase fish production and this insect survey is organized

Table 2.—Insects and other animals collected on improved and unimproved Michigan streams.

Name	Percentages Collected in Improved Streams		Percentages Collected in Unimproved Streams		Type
	Insects	Other Animals	Insects	Other Animals	
North branch Boardman river	93.4	6.6	70.1	29.9	Artificially improved in 1934
North branch Boardman river	14.6	85.4	14.6	85.4	Improvements in progress 1935, taken 30 miles up stream
Klacking creek	88.5	11.5	54.9	45.1	Artificially improved in 1935
Hunt creek	65.8	34.2	18.7	81.3	Artificially improved in 1934
Little Manistee river	95.7	4.3	65.2	34.8	Artificially improved in 1934
Canada creek	68.3	31.7	68	32	Artificially improved in 1935
Houghton creek	70	30	64.4	35.6	Artificially improved in 1934
Maple river	28.1	71.9	34.2	65.8	Artificially improved in 1935
East branch Fox creek	87.1	12.9	83.7	17.3	Artificially improved in 1934
South branch Au Sable river			58.1	41.9	None after dam was removed
Little Two-hearted river			89.6	10.4	Natural obstruction
Two-hearted river			79.2	20.8	Natural obstruction
Cannon creek			62.8	37.2	Natural obstruction
Manistee river			51.7	48.3	Natural obstruction

to determine the effect upon abundance of insects of the presence or absence of the alterations characterized as stream improvements.

Table 1 presents the general features of the streams studied during 1935.

After the streams had been selected for study, 12 stations were established on the improved streams, six stations in improved areas and six in unimproved areas of the same streams; and six stations in unimproved streams. These stations were established to include a representative bottom type of the entire stream as nearly as possible. It should be noted that to obtain a fair average of the insect population at any given point in the stream it is necessary to visit established stations more than once.

Table 3.—Insects and other animals collected on improved streams.

Name and No. Samples	Klacking Creek, 48		Houghton Creek, 48		Hunt Creek, 12		Little Manistee River, 65		Canada Creek 48		Maple River, 48		East Branch Fox Creek, 12		North Branch Boardman River, 65		North Branch Boardman River, 6	
	Im.	Un.	Im.	Un.	Im.	Un.	Im.	Un.	Im.	Un.	Im.	Un.	Im.	Un.	Im.	Un.	Im.	Un.
Trichoptera	1118	341	692	468	82	18	51	412	268	197	76	107	189	169	14	23	728	64
Ephemerida	115	26	24	39	1	1	7	213	46	74	21	89	38	76	5	4	52	62
Plecoptera	41	13	62	12	6	13	4	10	50	29	21	17	3	8	0	1	41	30
Odonata																		
Anisoptera	0	1	0	0	0	2	0	0	22	39	6	7	0	2	0	3	24	26
Zygoptera	0	0	0	0	0	0	0	0	13	10	0	1	0	0	0	0	0	1
Hemiptera																		
Corixidae	0	0	0	1	1	1	0	2	6	17	0	0	12	0	0	0	0	26
Nepidae	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gerridae	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3
Diptera																		
Tipulidae	63	23	30	59	2	5	16	78	15	19	3	12	8	21	39	11	127	61
Simulidae	1	0	0	0	0	0	0	213	0	0	37	12	5	2	1	1	12	14
Chironomidae	12	6	28	45	24	20	744	56	14	9	1	17	173	0	3	2	43	30
Tabanidae	15	10	10	15	0	0	4	6	18	10	0	0	0	0	0	0	136	59
Stratiomyiidae	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	47	22	126	127	17	0	1	6	13	32	5	9	3	4	9	2	61	20
Neuroptera	0	0	0	0	0	0	0	0	5	3	0	0	0	0	0	0	1	0
Lepidoptera	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Orthoptera	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
Other Animals																		
Arachnida													0	0		1	3	0
Chaetopoda	2	13	24	14	0	1	3	1	9	4	26	10	2	1	13	22	1	9
Crustacea	142	259	407	318	15	183	24	212	64	35	232	413	2	0	336	213	37	121
Gastropoda & Pelecypoda	35	87	34	64	54	67	7	309	137	161	153	95	42	41	109	34	46	34
Hirudinea	0	1	5	0	0	9	0	1	1	1	18	5	15	6	6	1	0	3
Amphibia	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Pisces	4	5	5	18	0	0	2	3	2	2	4	2	1	0	0	0	0	2
Cyclostomata	0		5	10	0	0	0	5	5	4	1	0	3	7	0	2	0	0

It may be noted in table 1 that the streams studied were sampled four and five times during August, September and October.

A bottom sampler, 1 square foot in area, and a scoop were used in taking the samples. Two inches of bottom were removed and placed in a 1-square-foot screen sieve. This was done to insure uniformity in sampling. After this was thoroughly washed, all animal life that could be seen

Table 4.—Insects and other animals collected on unimproved streams.

Name and No. Samples	Little Two-hearted River, 12	Two-hearted River, 12	Cannon Creek, 30	Manistee River, 30	South Branch Au Sable River, 6
Trichoptera	362	207	281	451	83
Ephemerida	22	37	90	97	3
Plecoptera	1	7	49	25	13
Odonata					
Anisoptera	2	13	23	46	4
Zygoptera	0	0	0	3	0
Hemiptera	0	0	3	11	0
Corixidae	0	9	0	0	0
Nepidae	0	0	0	0	0
Gerridae	0	0	0	0	0
Diptera					
Tipulidae	5	14	16	9	0
Simulidae	116	7	12	2	0
Chironomidae	0	3	30	10	0
Tabanidae	0	0	2	15	0
Rhagionidae	0	1	0	0	0
Syrphidae	0	1	0	0	0
Coleoptera	0	2	31	53	0
Neuroptera	0	0	1	10	0
Lepidoptera	0	0	0	1	0
Hymenoptera	0	0	0	1	0
Orthoptera	0	0	0	0	0
Other Animals					
Chaetopoda	0	0	61	103	12
Arachnida	36	0	0	0	0
Crustacea	0	0	209	48	3
Gastropoda and Pelecypoda	20	77	45	518	63
Hirudinea	1	2	1	7	1
Cyclostomata	0	0	1	1	0
Pisces	2	0	1	8	4

with the naked eye was removed and placed in a preservative made of 1 part formalin, 10 parts distilled water and 10 parts alcohol, with a label giving station number, date and name of stream for identification at a more opportune time.

Table 2 presents the percentage of the insects and other animals found on the streams studied; the type of "improvement"; and the time the alterations were made.

In all improved streams studied, with two exceptions, there was an increase in the percentage of insects compared with all animals taken in the improved areas over the unimproved areas. The two streams which show less insect life in the improved area are sand bottomed and con-

tain many beaver dams in the areas studied; also the improvements were in the process of construction.

Table 3 shows the classification of insects and other animals taken from the improved streams and their relative numbers.

It may be noted that the Maple river and north branch of the Boardman are very low in insect life and exceedingly high in other forms of animal life. This is probably due to their bottom type. Both have shifting sand bottoms. On the north branch of the Boardman, where improvements were installed in 1934, there was a decided increase in the numbers of insects present; this is due to the fact that more debris and rocks are exposed, as a portion of this stream has a fine gravel bottom which is covered by this shifting sand.

Table 4 represents the kinds and numbers of animal life taken from unimproved streams, which in some areas present ideal conditions for both trout and insects while other areas in the same streams do not present these conditions.

In the tabulations on the improved streams it may be noted that there was an increase of 16.7 per cent insect life in the improved areas of the streams studied, whereas when insects and other animals are considered there was 8.9 per cent increase of living organisms in the improved areas over the unimproved.

In the five unimproved but naturally good trout streams studied, it may also be noted that 64.2 per cent of all the living animals present were insects and 35.8 per cent others.

Conclusion.—It would seem that the data presented indicate an increase in the insect fauna of improved over unimproved streams. This is in accordance with results obtained in 1934. In most cases there is a decided increase in the insect life in these improved areas and a decrease in other animal life.—1-4-36.

LIQUID APPLICATIONS TO CONTROL PEACH BORER AND LESSER PEACH BORER

S. C. CHANDLER, *Illinois State Natural History Survey, Carbondale*

For the last three seasons tests have been conducted by the writer at Carbondale in southern Illinois for control of the peach borer, *Conopia exitiosa* Say, and for the lesser peach borer, *C. pictipes* G. & R. The accompanying tables summarize most of the results obtained.

Considering first the peach borer tests, attention is called to table 1. Treatment No. 1 is crystalline paradichlorobenzene, hereafter given the more common name of PDB, used in the regular manner at the rate of 1 ounce per 10-year-old tree. This treatment is used as a standard. In treatments 2 and 3 the crystals were dissolved in miscible oils at a rate suggested by Snapp, in Georgia, 2 pounds to 1 gallon, and diluted with water so that each pint contained 1 ounce. Since each tree received 1 pint

the amount of PDB was the same as in the standard. In treatment 4 a reduction in the amount of soybean oil was used to allow for the fish-oil soap and water with which this oil must be emulsified. The final dilution was the same as for Nos. 2 and 3. Treatments 5 and 6 were applied exactly according to the manufacturer's directions. In No. 5, one-half

Table 1.—Summary of tests for control of peach borer.

No.	Treatment	No. Seasons	No. Trees	Total Borers	Per Cent Dead
1	PDB crystals, 1 oz. per tree	3	50	129	95.4
2	PDB in *Dendrol*, 1 oz. to 1 pint	3	30	83	96.3
3	PDB in *Scalecide*, 1 oz. to 1 pint	2	20	51	96
4	PDB in soybean oil, 1 oz. to 1 pint	2	20	34	91.1
5	PDB in *Scalecide*, dilute	1	10	29	58.7
6	*Scalecide* 1:7, (no PDB)	2	20	45	22.2
7	Dichloropentane, 1 oz. per tree	2	20	53	69.8
8	Dichloropentane, 2 oz. per tree	3	30	87	95.4
9	Check	3	35	103	2.9

pound of PDB was dissolved in 1 gallon of *Scalecide* and diluted with seven parts of water, one-fifth gallon being applied per tree. In No. 6 no PDB was used in the *Scalecide*. The oil was diluted with seven parts of water and 1 quart sprayed per tree after removing the dirt from the base of the tree and rubbing off wax and gum as for worming. In Nos. 7 and 8 the liquid dichloropentane was used at the rate of 1 and 2 ounces by weight per tree. In all of the treatments except No. 6, trees were mounded in the usual manner after treatment.

Table 2.—Summary of tests for control of lesser peach borer.

No.	Treatment	No. Seasons	No. Trees	Total Borers	Per Cent Dead
1	PDB in *Dendrol*, 1 oz. to 1 pint	2	25	31	61.2
2	PDB in *Dendrol*, 2 oz. to 1 pint	3	35	45	82.2
3	Dichloropentane	1	16	24	70.8
4	PDB in soybean oil	1	10	23	4.3
5	Check	2	20	26	0

The last column of tables 1 and 2 gives the percentage of borers found dead in the course of the examinations made two weeks after treatment. Considering first the treatments of PDB in oils, it will be seen that when used at a strength equal to the crystalline form the results were practically the same, averaging 95 to 96 per cent dead as compared with 2.9 per cent in the check. PDB in soybean-oil emulsion, however, appears somewhat inferior, but is very close with a 91.1 per cent average. It is very apparent that when used at too weak a mixture or without PDB

the results with oils are unsatisfactory. Dichloropentane when used at a strength of 2 ounces per tree (by weight) also gave 95 per cent kill. No injury has yet been found in any of the treated trees.

The practical value of using the liquid treatments has not been demonstrated. The principal advantages claimed for the liquid treatments over the dry or crystalline treatment are: (1) they can be applied to young trees with no fear of injury, and (2) the work can be done more quickly with a spray machine. The first advantage claimed is of little value in this section. In Illinois we have for years treated trees only one year old with PDB crystals with no injury whatever. The second advantage claimed is problematical. To make a change to the liquid application worth his while a grower must apply the liquid in a sufficiently shorter time than he does the crystals to compensate for the additional expense of the spray machine and team and for the cost of the liquid carrier. The approximate cost of the cheapest of the three oils used would be one cent per tree, which is the same as the cost of the one ounce of PDB. Thus the total cost of materials per tree is double that of the crystalline applications. In the case of dichloropentane, however, the cost is approximately the same, one cent per tree. It is just possible that this material would not have to be covered with a mound, in which case there would be some advantage from a cost standpoint in this material. The practical value of these materials for the control of the peach borer is a matter for the grower to decide.

With the lesser peach borer, however, we have a different situation. There is no control except the unsatisfactory jackknife and wire method. If we can find an economical paint that will give a good control of borers in crotches and wounds we shall fill a long-felt need. Table 2 gives the results of tests with three of the above materials for the control of this insect. It is plain that the most promising material used was PDB dissolved in 1 gallon of *Dendrol* and diluted with water so that each pint contained 2 ounces of PDB. This is double the strength found so effective against the peach borer. It is possible that by increasing the amount of PDB to greater than the original 2 pounds per gallon of oil a dilution could be found that would give a still better kill than the 82 per cent recorded in table 2. The author believes that an 82 per cent average kill for three seasons is satisfactory for the lesser peach borer. The material was painted on the injured areas liberally. The wax was not removed before painting. In these tests 1 pint treated, on the average, seven and one-half trees. The cost is about four cents per pint, or approximately one-half cent per tree.

To date no injury has been observed in any of the treated trees with either of these two insects.—1-23-36.

ACCORDING TO a recent report from G. M. Bentley, state entomologist and plant pathologist of the Tennessee Department of Agriculture, his office is now located in their new quarters. His department occupies all of the first floor of the new fireproof five-story biology building and in addition has two large insectaries. On the staff of the office are O. E. Couch, L. K. Smartt, J. C. Moser, E. P. Deuberry, Dudley D. Thompson and Howard L. Bruer, nursery inspectors, Julian Allison, apiary inspector, and A. N. Pratt, field horticulturist.

TESTS ON BAITS FOR ORIENTAL FRUIT MOTH, 1935[1]

S. W. Frost, *The Pennsylvania State College Research Laboratory, Arendtsville*

Fifty-five chemicals were tested as attrahents for the adults of the oriental fruit moth, *Grapholitha molesta* Busck. The tests were conducted in the manner described by the author in 1934,[2] except that gallon aluminum traps were used from April 30 to July 26, then one-quart, wide-mouthed glass jars were substituted. A 1:20 solution of a medium grade refiner's syrup, sucrose 37.9 per cent and reducing dextrose 19.4 per cent, was used as a bait to which the various attrahents were added at the rate of 1 cc. or 1 gram per trap. Succinic, salicylic and acetic acids, propyl acetate, ethyl citrate and ethyl succinate, being readily soluble in water, were added directly to the syrup solution. Anisic acid and benzyl cinnamate were dissolved in alcohol before being added to the bait. This procedure was not satisfactory because alcohol is attractive to the oriental fruit moths. Apiol, salol and durene were dissolved in mineral oil and then emulsified, as well as all other chemicals, using 10

Table 1.—Oriental fruit moth populations in Adams county peach orchards.

Orchard	Number Moths Taken from 10 Traps	
	1932	*1935*
1	24	637
2		2539
3	626	639
4		609
5	127	590
6		423
7	1359	566

grams of acacia and 80 cc. water. The acacia was dissolved in hot water to hasten the process, but the solution was cooled before adding the volatile attrahents. It is an excellent emulsifying agent because it is inert, does not react with the chemicals, and, judging from the tests conducted during 1935, has no attraction for the oriental fruit moth. One short test was conducted with methyl cinnamate, using *Albasol BF*, a commercial product, as an emulsifying agent. The results were not satisfactory. Five sets of traps with safrol served as checks. These were distributed evenly throughout the orchard and caught respectively 72, 57, 53, 47, and 44 moths between September 8 and October 9. This indicates that the oriental fruit moths were quite uniformly distributed.

Ten traps were used in each test in table 2, and corrections have been made for traps that fell during the course of the experiment.

The selection of the orchard in which to conduct these tests was determined from bait traps observed during 1932 and 1935. Prior to 1932, orchard No. 5, table 1, showed a heavy infestation. In 1932 the moth population fell considerably in this orchard while orchard No. 7 showed a heavy infestation. As a result the work was shifted to orchard No. 7,

[1] Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as technical paper 711.

[2] Jour. Econ. Ent. 28(2):366-9. Apr.

where the tests were conducted during 1933, 1934 and 1935. In 1935 the infestation fell noticeably in this orchard and it is apparent that orchard No. 2 will be a desirable place for 1936 tests. It is suspected that the continued use of a large number of traps in these orchards for several years has reduced the infestation.

Table 2.—Chemotropic responses of the oriental fruit moth.

Attrahents	Number Moths Taken from 10 Traps				
	May–June	June–July	July–Aug.	Aug.–Oct.	Totals
No attrahent	88	30	122	80	320
Acacia	91	52	148	64	355
Safrol	44	571	179	72	866
Iso safrol	24	217	283	102	626
Eugenol	38	907	81	71	1093
Linalool	46	45	254	70	415
Anethol	31	120	432	307	890
Apiol	24	127	238	125	514
Salol	11	12			23
Myrtol	47	71	361		479
Nerol	37	539	216		792
Phenetol			219	73	292
Eucalyptol				200	200
Furfural, C. P.	17	57	404	96	574
Furfural, technical	17	24	330	76	450
Linolic acid	19	870	404	232	1525
Anisic acid	76	290	586	119	1071
Succinic acid	46	97	392	130	665
Salicylic acid	57	353	40	60	510
Oleic acid, commercial	26	40	410	217	693
Oleic acid, linolic free	35	100	597	274	1006
Oleic acid, U.S.P.	39	352	506	205	1102
Acetic acid, glacial	102	91	685	340	1218
Propyl acetate	122	84	390	86	682
Amyl acetate	94	67	329	128	618
Linalyl acetate			517	180	697
Cinnamyl acetate			105	116	221
Benzyl acetate			90	98	188
Ethyl acetate			166	107	273
Methyl acetate			106	85	191
Butyl acetate			121	56	177
Heptyl acetate				92	92
Anisic aldehyde	42	950	74	48	1114
Ethyl citrate	155	42	342	84	623
Ethyl formate	46	18	352	65	481
Ethyl salicylate	29	63	130	27	249
Ethyl succinate	60	221	135		416
Ethyl valeriate	43		161	87	291
Ethyl cinnamate			144	120	264
Benzyl cinnamate			179	102	281
Iso butyl cinnamate			215	84	299
Methyl cinnamate				28	28
Dipentene	21	20			41
Cinnamene	118	305			423
Cymene	31	19	290	57	397
Durene	21				21
Styrene				199	199
Aldehyde C-14, peach	7	9			16
Oil, clove	35	228	54	13	330
Oil, olive	33	53	226	274	586
Oil, camphor	28	82	380	196	686
Oil, citronella	20	95	236	62	413
Oil, carroway	28	55	239	111	433
Oil, sweet majoram	35	14			49
Oil, laurel	51	13			64
Oil, linseed	73	146	329	245	793

To designate more completely the brand or type of certain chemicals used in the tests, the following list is given. All, except those otherwise indicated, were purchased from Eimer & Amend, Third Avenue, 18–19 Street, New York.

Anethol, practical (Fisher).
Apiol, green from parsley.
Amyl acetate, technical solvent.
Salol, phenylsalicylate crystals.

Myrtol, a mixture of $C_{10}H_{16}$ $\cdot C_{10}H_{18}O$ and $C_{10}H_{16}O$ (Merck).
Nerol (Givaudan & Delawanna).
Phenetol, phenylethyl ether.
Furfural, C. P.
Furfural, pyromucic aldehyde, technical.
Linolic acid, C.P.
Anisic acid, crystals.
Succinic acid, crystals (Baker).
Salicylic acid, crystals.
Oleic acid, commercial.
Oleic acid, linolic acid free.
Oleic acid, U.S.P. clear.
Acetic acid, glacial.
Propyl acetate, C.P. normal.
Linalyl acetate, (Givaudan & Delawanna).
Cinnamyl acetate (Givaudan & Delawanna).
Ethyl citrate, C.P.
Ethyl succinate, C.P.
Iso butyl cinnamate (Givaudan & Delawanna).
Dipentene or cinene, technical (Eastman).
Cinnamene or styrene (Eastman).
Cymene or cymol, para technical.
Durene, crystals (Eastman).
Aldehyde C-14, peach (Givaudan & Delawanna).
Oil, sweet majoram, essential.
Oil, laurel (*Oleum laurinum*).

Quart-glass traps can be operated with less labor, syrup and water than gallon aluminum traps and apparently there is little difference in the catch from these traps when they are strained once a week. It is questionable whether similar results could be obtained if the baits in quart-glass traps were to be left undisturbed for a period of four or five weeks. For

Table 3.—Details of operation of traps.

Duration of Tests	Type of Traps	No. Traps	Gallons Water Added Weekly	No. Traps Down
April 10–June 12	gallon aluminum	430	226	8
June 13–July 26	gallon aluminum	430	73	18
July 27–Sept. 9	quart glass	450	58	4
Sept. 10–Oct. 7	quart glass	460	46	1

experimental purposes, however, the quart-glass containers proved more satisfactory and were used entirely after July 26. It is evident from table 3 that they required less water to keep them filled to the proper level each week.

The captures for 1935 were very low compared with preceding years and the results therefore not as conclusive. Acids hold a prominent place as attrahents for the adults of the oriental fruit moth. Oleic acid, U.S.P., and oleic acid, linolic free, were more attractive than commercial oleic

Table 4.—Promising attrahents for 1935.

Attrahent	No. Oriental Fruit Moths Attracted	Cost per Trap
Linolic acid	1525	$.04
Acetic acid	1218	.0013
Anisic aldehyde	1114	.0214
Oleic acid, U.S.P.	1102	.0008
Eugenol	1093	.0125
Anisic acid	1071	.05
Oleic acid, linolic free	1006	.0214
Anethol	890	.0022
Safrol	866	.0022
Linseed oil	793	.0009

acid. This is strange since linolic acid was very attractive and linseed oil stood among the 10 best materials for 1935. Linalool and propyl acetate, which ranked high in 1934, do not appear in the list for 1935. These variations may be due to seasonal conditions, some materials working better at higher temperatures than others. Conclusions on this point will be reached after the chemicals have been tried for several successive seasons.

Other materials such as eucalyptol, linalyl acetate and cinnamene, lend some promise. Although they were tested for only a few weeks, the catches for this period indicate that they compare favorably with the chemicals indicated in table 4.—7-3-36.

SECTION OF EXTENSION ENTOMOLOGY

FIGHTING CHINCH BUGS IN IOWA

A. D. Worthington and G. C. Decker, *Iowa State College, Ames*

The purpose of this paper is to describe briefly the organization and methods used in controlling chinch bugs and to emphasize the results that may be secured when a carefully planned educational program and a well-coordinated campaign is conducted. In the present outbreak the bugs became sufficiently abundant to warrant the application of control measures in 1932. Favorable weather in 1933 and 1934 permitted the chinch bugs to increase to such an extent that it was necessary to use control measures in 50 Iowa counties in 1934.

Since 1932 the Extension Service has cooperated with the Bureau of Entomology and Plant Quarantine, the state department of agriculture and the agricultural experiment station in conducting successful chinch bug-control campaigns. A thorough educational program supported by a carefully planned and selected organization formed the backbone of the program and was responsible for the success of the campaign. For several years Iowa has attacked important insect-control problems by uniting all of the important agricultural agencies of the state under a state central committee and this plan was wisely followed in all of the chinch bug campaigns. Therefore, when the U. S. Department of Agriculture entered the fight in 1934 and 1935, Iowa was fortunate in having the desired state set-up which had already been in action for over a year.

The complete organization consisted of a state committee, a state leader, three assistant state leaders, county leaders, county committees and township cooperators. Great care was used in selecting men for the organization who were vitally interested in the chinch bug problem and could be depended upon to do their part in making the campaign a success. Definite duties were then assigned to each individual in the organization. The state committee, consisting of Mr. Ray Murray, secretary of agriculture; Mr. R. K. Bliss, director of the Extension Service; Dr. R. E. Buchanan, director of the experiment station, and Dr. C. J. Drake,

state entomologist, was responsible for the coordination of the work. The state entomologist was appointed state leader and he in turn appointed the extension entomologist, an experiment station entomologist and the assistant secretary of agriculture as assistant state leaders. The extension entomologist was responsible for the educational and organizational work; the experiment station entomologist for the field experimental work, and the assistant secretary of agriculture for the distribution of the barrier materials. In each county the agricultural agent was named county leader and made responsible for the supervision of the campaign. He selected the county committee and cooperators in each township. The county committee usually consisted of the mayor of the county seat, the county engineer, the county relief director and a member of the board of supervisors. The township cooperators were not selected because they were directors of farm organizations, chairmen of school boards or other organizations, but rather because they were progressive farmers who were personally interested in the chinch bug problem and actually had bugs to fight on their own farms. The cooperators were asked to report conditions in their vicinity and to assist in building and maintaining model barriers on their farms. These barriers served as construction models and also as result demonstration barriers for the township. Thousands of farmers visited these barriers to see how good barriers should be constructed and to observe the barriers in operation.

Each year the campaign was preceded by a thorough survey in the counties which seemed likely to be heavily infested with chinch bugs and the findings of this survey served as a motive for starting the chinch bug-control meetings and publicity. These educational meetings had as their objectives: selling the people the need for an organized campaign, setting up an organization in the counties and townships, convincing the farmers of the value of control and to induce a maximum number of them to keep chinch bug damage down to a minimum. All of this was necessary because the chinch bug problem was new to most Iowa farmers. It should be noted that with the exception of a small area in the southern part of the state in 1922–24, Iowa had been entirely free of chinch bug losses from 1902 until the present outbreak.

The educational program was started in district county-agent schools at which the chinch bug problem, organization, and methods of control, were discussed and tentative plans were made for county campaigns. These schools were followed by winter meetings which were set up by the county agents in each county. This was a county-wide meeting, and the agent made a strenuous effort to get two farmers from each township and the Smith-Hughes instructors to attend the meeting. In this way the nucleus of an organization in each township was assured. Following the winter meeting the county agent, Smith-Hughes instructors and local leaders discussed the problem with smaller groups and gave the chinch bug information to the farmers in each township. In this way interest was developed and paved the way for a successful second meeting to be conducted in April or May. At the latter meeting the results of the spring survey (populations in small grain) were given, the importance of the problem was emphasized, control methods were fully explained, local

cooperators were selected and the names of the farmers on whose farms model barriers would be constructed were announced.

The spring meetings were followed by barrier construction demonstrations, which were conducted by the extension entomologist or one of his assistants, were usually held early in June. At these demonstrations the farmers were actually shown how to build the different types of barriers and the advantages and disadvantages of the various types were discussed. The county-wide demonstration was followed by township demonstrations conducted by the county agent and Smith Hughes instructors. They were held on the farms of the cooperators named at the spring meetings and whenever possible these demonstrations were timed so as to show the barriers in operation. In addition to the demonstration barriers small sample barriers were arranged to demonstrate common errors such as: improperly placed post holes, poor furrows, irregular creosote lines, poorly built paper fences and inadequate maintenance. The value of these demonstrations of common errors cannot be over emphasized. They were used effectively by the speakers in stressing their appeal for proper construction and adequate maintenance of barriers.

The entomologists were kept in the field throughout the spring and early summer months and county leaders and cooperators were given weekly reports on the chinch bug situation. The field entomologists reported daily to the state leader and county leaders could at all times secure reliable information regarding the chinch bug situation in their respective counties or the state from the state leader. Constant observations in the field are necessary because it is not possible to know the actual situation from week to week if such observations are not made. Some unreliable or misinformed individuals often have the chinch bugs eating up wheat in March or have the bugs entirely destroyed by rain or disease. Such false reports are only corrected by giving the actual conditions as found by competent observers. These service observations are essential if one attempts to determine the quantity of creosote needed and the time when such material should be shipped into a county. The county leaders are not always capable of fully evaluating the situation and in seasons such as 1935 these observations should be continued through May, June and July. The surveys in the spring and summer also serve as a source of information from which chinch bug stories of a local nature can be given to county papers.

The educational meetings were supplemented by timely newspaper articles, educational exhibits and radio talks. In preparing news articles, an effort was made to have a weekly story in all county papers which would contain some current information on the local situation. The radio talks were usually of the open-forum type in which a series of questions and answers were used. Educational exhibits were found to be a splendid means of getting information to the farmers. In 1934, 10 exhibits were prepared for the state fair, sectional and county fairs. Numerous farmers attending winter meetings reported visiting chinch bug exhibits and securing much valuable information from them. These exhibits created interest and often sold the farmers on the value of the program.

Two types of control are used in Iowa, namely, crop planning and

barriers. Crop planning is used only in a limited way. On individual farms where practical the small-grain acreage was reduced as much as possible and the fields were arranged so as to reduce the need for barriers. Generally speaking, a radical change in farming practices or a drastic change in crops normally grown in Iowa was not recommended as a control. As long as chinch bugs in Iowa continue to come in sporadic outbreaks, as in the past, it does not seem practical to recommend a drastic change in the present cropping system. In Iowa the money crops are corn, small grain and hogs, and a change to chinch bug-resistant crops would force the farmer to buy new machinery, discard old machinery, alter fencing, change crop rotations, reduce livestock production and change his budget. Such changes would cost millions of dollars and naturally would not be a practical control measure under present conditions. The most serious chinch bug damage in the history of Iowa occurred in 1934, when the estimated losses were $30,000,000. On the other hand, if drastic changes in farming practices had taken place they would have cost the farmers more than the losses caused by the chinch bugs. Furthermore, once established, the new cropping system, with its reduced net income, would probably remain after the bugs were gone and thereby reduce the farmers' net income over a period of years.

Since the use of resistant and immune crops is limited, the creosote fences and barriers are regarded as the most effective emergency method of control. Two types of chemical barriers are now in general use, namely, the creosote-treated paper fence, and the combination furrow–creosote line. Paper fences were first used in experimental work in the state of Iowa in 1933, and since then they have become not only the most effective but also the most popular type of barrier. This barrier was widely used and gave splendid results in Iowa in 1934 and 1935. From the extension or field entomologist standpoint the paper fence was by far the best type of barrier. Approximately 50 per cent of the furrow–creosote-line barriers were unsatisfactory because of faulty construction. In contrast, over 80 per cent of the paper fences constructed by farmers gave very satisfactory results. The average farmer almost invariably built a satisfactory paper fence whereas he often failed to construct a good furrow-type barrier. Farmers are professionals in building wire fences and they realize the importance of good fences, and they therefore, realized the necessity of building a "chinch bug-tight" fence. Also the average farmer can readily see how a fence type of barrier can stop chinch bugs, but he has to be shown that a mere line of creosote on a ridge will stop the bugs. Furthermore, many farmers often ask the question, "If a creosote line will do the work, why won't any old line be good enough to stop the bug?"

The paper fence has several advantages over the furrow creosote barrier. They are: cheaper to construct and maintain; require less attention after being built; turn bugs more effectively in windy weather and form an effective barrier in all types of soil. Also, the necessary materials for constructing paper fences are available in all Iowa towns, and the barriers can be constructed a week to 10 days in advance of migration without serious deterioration of the fence.

The furrow–creosote barrier will give splendid results when properly built and maintained, except during windy weather. However, this type of barrier requires more attention and in many cases a fairly good-appearing barrier fails to give the desired results, because the builder neglected to smooth the furrow and remove the clods, placed the creosote line in the wrong place or left abrupt turns and sharp curves in the chemical line.

The results of the campaigns conducted during the past three years were very satisfactory. In 1933, 122 meetings were held in 26 counties with an attendance of 5126 farmers. The farmers used 100,000 gallons of creosote and gas tar in constructing 500 miles of barriers which protected 300,000 acres of corn. The total value of the corn crop saved was approximately $6,000,000. In 1934 chinch bug control campaigns were conducted in 50 counties, and a total of 63,000 persons were in attendance at 584 meetings. Over 3,200,000 gallons of creosote and gas tar were used in constructing 15,000 miles of paper fence and creosote–furrow barriers, to protect 2,400,000 acres of corn. The value of corn saved from the first generation of chinch bugs has been conservatively estimated at $15,000,000. In 1935, 290 chinch bug-control meetings were conducted in 75 Iowa counties with a total attendance of 26,220 persons. Approximately 50,000 gallons of creosote were used in constructing 300 miles of barriers. The barriers protected 25,000 acres of corn and saved the farmers about $375,000.—4-15-35.

OBTAINING COOPERATION OF GROWERS IN STUDYING SPRAY SCHEDULES[1]

GEORGE D. JONES, *University of Missouri Agricultural Extension Service, Columbia*

Opinions of Missouri apple growers in 1935 varied as to which sprays and schedules were most effective in controlling the codling moth. Disagreement on such matters is not unusual but this time the College of Agriculture entomologists decided to take advantage of the situation. They would assist orchardists in various localities to experiment with selected safe sprays and schedules. Then the orchardists could decide for themselves which one or ones they preferred to use.

In developing the details of the plan, it was considered important that the extension entomologist or a worker from the department oversee the experimental work done in each orchard. It was also thought wise to limit the number of cooperators to one or two in a county as it would be difficult for one field worker to assist a larger number efficiently. These cooperators usually were men recommended by the county agent.

In laying out the orchard test blocks, such factors as age of trees, variety, and previous infestation were considered. In order that the grower would be able to carry out the tests with as little inconvenience as possible, the blocks used were the area that one tank of spray would

[1] Contribution from the Department of Entomology, Missouri Agricultural Experiment Station, Journal series 474.

cover. For instance, if the grower used a 300-gallon tank, sprayed two rows at a time, and put approximately 10 gallons of spray on each tree, the blocks would be approximately 15 trees long. When more than one spray schedule was used, the different test blocks were adjacent. The growers in all the orchards were agreeable to the use of a block treated with an arsenate of lead spray as the measure of comparison. No unsprayed trees were left for checking purposes.

A number of spray schedules were suggested to the orchardists in response to their requests. The growers were asked to test one or more safe sprays or schedules that differed from their regular spraying program. One man wanted to compare a block sprayed with arsenate of lead on a seven-day schedule against a block sprayed on a 10-day schedule. In one case a grower had never used oil and he wanted to compare the effectiveness of his arsenate of lead spray with an arsenate of lead and oil combination. Others wanted to try different combinations of arsenate of lead and oil. As long as a safe program was being followed, the grower was allowed to choose the combinations he thought would fit his needs best. The orchardist furnished the materials and applied them as recommended. He also kept a codling moth emergence cage and checked catches.

Some three or four trees were selected in each block to serve as count trees. Counts were made on the degree of first and second-brood injury, and final counts were made prior to harvest. Spray residue tests were made and if difficulty was encountered in removing excess residue, the fact was noted in the seasonal report.

The 1935 season was such that practically all spray materials used in a suggested schedule gave good control regardless of what program was chosen by the growers.

Some of the desirable features of such a program are as follows:

An orchardist can thus prove to his own satisfaction that a different spray material or system of application is more or less satisfactory than his usual spray program; the orchardist develops a keener interest in the whole spray problem and he gains a greater appreciation of experimental procedure and data; it shows the cooperators the need of watching results from a certain practice in his orchard over a longer period than one year; it gives experiment station workers a chance to observe how a recommendation is used by a grower; it presents station and field workers with an opportunity to get in closer touch with the growers, learn more of their problems, and note how recommendations may apply under the many different conditions found in a large state.—7-11-36.

RASPBERRY PLANTS shipped into New Jersey, or within the state, are required to be twice inspected for virus diseases during the growing season, under regulations placed by the New Jersey State Board of Agriculture on March 24.

A LIST OF 15 articles determined as exempt from certification under the Japanese beetle quarantine was issued by the Bureau of Entomology and Plant Quarantine on June 1 as Circular BEPQ-395. A revised list of true bulbs, corms and tubers, in relation to certification requirements of the quarantine was also issued on the same date, as Circular BEPQ-394, superseding PQCA-274.

SECTION OF PLANT QUARANTINE AND INSPECTION

RECENT DEVELOPMENTS IN CANADIAN REGULATORY WORK

L. S. McLaine, *Entomological Branch, Ottawa, Canada*

Review of the activities of the Plant Inspection Service in Canada, including important changes in legislation, developments in import and export inspection services, summary of the gypsy moth and European corn borer situation, preventive work for the Dutch elm disease and Japanese beetle, precautions taken at the World's Grain Conference, cooperative work with the provinces in apple maggot control, precautions taken with regard to the export of apples, and mention of the vacuum fumigation equipment installed at Montreal.

A previous paper dealing with regulatory work in Canada was presented before this section at the New York meetings seven years ago. Since then there have been many changes and developments in this work not only as regards legislation but also in field activities.

In December 1928, Canada had under the Destructive Insect and Pest Act a series of "General Regulations," 16 foreign regulations and seven domestic regulations, making a total of 24 regulations in all. This number has now been increased to 28, made up by the addition of three foreign regulations and one export regulation. These additions, however, do not take into account changes in existing regulations which have taken place from time to time as necessity arose. During this same period two regulations (one foreign and one domestic) dealing with the gladiolus thrips were passed but were rescinded after being in force two years.

From the legal point of view the most important development during the period under review was the amending of the Destructive Insect and Pest Act. This act passed in 1910, remained untouched until 1932, when certain constitutional issues arose similar to those which led to the amending of the Plant Quarantine Act of the United States in 1926. Although the question of the Dominion Department of Agriculture covering the entire field of insect and pest legislation was never tested in Canada before the courts, nevertheless it was felt by certain of the provinces that such was the case and if court action were taken with regard to provincial legislation such legislation would be declared *ultra vires*. To overcome this difficulty the act was amended so as to enable the various provinces to pass legislation dealing with the control of insect pests or plant diseases within the province, provided that such provincial legislation did not conflict with federal legislation then in force or enacted at some later date. Clauses were also inserted to enable regulations to be passed to prevent the export of any insect, pest or disease destructive to vegetation or to prevent the export of any vegetable or other matter likely to carry any such pest or disease and, furthermore, to provide for the inspection and certification of vegetable or other matter for export or for domestic purposes.

In 1934, a constitutional point was raised with regard to the section empowering the provinces to pass legislation, and to clarify this section

the act was again amended without changing the intent of the amendment of 1932.

In so far as the import inspection service is concerned there have been no radical changes in this work during the past few years, apart from the fact that in 1932 the inspection service, formerly maintained by the province of British Columbia and the staff of which acted as collaborators of the department, was formally taken over. This change brought about a definite coordination of the work. In consequence, the federal department is now solely responsible for the inspection of import and export shipments of plants and plant products. Since the economic collapse there has been a decrease in the quantity of plants imported into Canada from other countries. This decrease, however, in quantities has not meant any decrease in the actual work but has permitted a closer inspection of the material imported and also an extension of the inspection of the quantities of plant products. It is gratifying to state also that, for the most part, in spite of the decreased values in plants generally, there has been a marked increase in the quality of the material shipped to Canada from other countries.

The principal changes in the regulations dealing with imports include the extension of the list of pines prohibited entry into Canada to include those species susceptible to attack by the European pine-shoot moth, in addition to those species which serve as hosts for the white pine blister rust.

A regulation was passed (1934) restricting the importation of peach and nectarine stock, etc., on account of the phony peach disease. This regulation was drawn up in accordance with the recommendation of the National Plant Board. Peach stock imported into Canada from the United States must now be covered by a certificate to the effect that it originated in a nursery which has been inspected and found free from the phony peach disease and also that the said stock is free from the peach borer.

In 1930 a regulation was passed prohibiting the importation of all species and varieties of wheat (including straw, bran and chaff) from Australia and Asia on account of flag smut, unless each shipment was accompanied by a certificate to the effect that the commodity was harvested in a locality where flag smut is not known to occur.

In 1934 the importation of tobacco seed from Australia and the United States was prohibited on account of the blue mould disease, which is not known to occur in Canada.

At the meetings of this section held in 1928, a resolution was adopted pointing out the danger of the unrestricted introduction of diseases of plants for study by individuals, etc. It may be of interest to note that a regulation is now in force which prohibits the importation of any living insect in any stage except the honey bee, pest or fungus or bacterium destructive to vegetation, unless a permit is first procured. The permit must be presented to the Collector of Customs at the part of entry before the importation may be released. This regulation is being strictly enforced and precautions are taken with regard to the issuance of permits. The cooperation of scientific workers and institutions has been se-

cured and in so far as is known no great hardship has resulted, although in certain cases permits have been refused.

Owing to the importance of elms as shade trees, particularly in eastern Canada, the discovery of an outbreak of the Dutch elm disease in the vicinity of New York has been the cause of a great deal of concern. Elms have been prohibited entry into Canada for a number of years and elms imported previous to the embargo prohibiting their entry were examined from time to time. In 1934 the regulation was amended, as a result of which the importation of elms, elm logs and burls, etc., from any country is prohibited.

During the present year a survey was carried on at the various seaports to determine the types of wood used in the construction of packing cases or to reinforce such cases. At one of the larger ports during the past season it was found that approximately 38,000 packages of china, glass or pottery entered in one season. The different types of wood used in the construction of these cases were the following: hazel, chestnut, willow, birch, elder, ash, oak and maple; on two occasions pieces of elm were found. Live insects were continually being found in crates and packing cases but the adults so far identified were confined to two species, namely the cerambycid *Gracilia minuta* F. and the scolytid *Leperisinus fraxini* Marsh. The pieces of elm found were free of insects or disease. The scolytid on ash was extremely abundant and in order to attain some idea of its prevalence a careful examination was made of the crates coming from one steamer. Of 74 crates examined, 56, or 76 per cent, contained ash wood; of these 34, or 46 per cent, of the total number of crates were found infested with *Leperisinus fraxini*. Steps were taken to secure the cooperation of importers by having them destroy all infested crates as soon as they were unpacked. In addition, all inspectors were instructed to keep constant watch on the condition of elms in their district and suspicious material was sent to the various plant pathological laboratories for examination. Fortunately, no sign of the Dutch elm disease has been found in Canada.

The gypsy moth outbreak which was found in southern Quebec in 1924 was eradicated after the expenditure of approximately $125,000, and in 1928 the quarantine placed on the movement of products from the infested and so-called danger zones was removed. Owing to the occurrence of frequent outbreaks of this pest adjacent to the Canadian border, scouting is being carried on each year as a precautionary measure.

The approach of the Japanese beetle to Canadian territory is a situation that is viewed with considerable alarm. Beetles have been found at Detroit, Mich.; Buffalo, Niagara Falls and Rochester, N. Y.; as well as at several northern points in Maine, New Hampshire and Vermont. During the summer season extra precautions, including the inspection of fruits and vegetables, automobiles and through freight from the heavily infested area, etc., have been carried out for a number of years at Yarmouth, N. S.; Saint John, N. B.; Montreal, P. Q.; Toronto, Niagara Falls, Fort Erie and Windsor, Ont. On many occasions dead beetles have been found in freight cars, automobiles, etc. Extensive trapping operations are also being carried on each season, particularly in the

Niagara peninsula, which is regarded as the most vulnerable point. This district adjacent to Buffalo and Niagara Falls, N. Y., and bordered by lakes Ontario and Erie, is one of our largest fruit-growing areas. Peaches, early apples, grapes and other fruits are grown in large quantities, as well as early vegetables. In this same area are located the majority of the larger nurseries. Trapping operations were also carried on at other ports in the vicinity of railway yards, steamship docks, etc. Thus far no infestation of the Japanese beetle has been found in Canada.

Little change has taken place in the European corn borer situation in Ontario although a marked increase has been noted in eastern Quebec, particularly in the market-garden section surrounding Montreal. The federal department carries on scouting to determine spread and maintains a quarantine covering the inspection and certification of certain products moving out of the infested area. The provinces are responsible for the control of the insect within their respective areas and in the case of Ontario and Quebec compulsory clean-up regulations are enforced by the respective provinces.

Progress has been made in connection with the control of the European pine-shoot moth, which has been prevalent in the Montreal, P. Q.; Toronto, Niagara Falls and Windsor, Ont. districts. The severe winter of 1933–34 undoubtedly assisted in bringing this pest within bounds. Special attention has been paid to nurseries and with a few exceptions the majority can be regarded as free from infestation.

The satin moth has been abundant in British Columbia for a number of years but as a result of the introduction of parasites the pest is being brought under control. In the maritime provinces the insect has increased, especially on Prince Edward Island and in certain sections of Nova Scotia. The introduction of parasites in the older known infested areas has already proved beneficial and additional colonies will be liberated as soon as possible. It is to be hoped that this pest will be brought under control, as is the case in New England, by the use of its natural enemies.

In the summer of 1933 the World's Grain Exhibition and Conference was held at Regina, Sask. Exhibits both for competition and display consisting of grains of all kinds, such as corn, wheat, oats, barley, rye, peas, beans, flax, Soya beans, hemp, buckwheat, millet, rice and grasses, clover, sunflowers, collections of vegetable seeds, etc., were received from countries all over the world. In view of the insect damage that occurred at the world's fair held in Chicago in 1893, and the number of different species that were found in imported material, as well as the danger of introducing new plant diseases, it was evident that all possible precautions would have to be taken. The protective work was divided into two groups—first, the prevention of the introduction of new species and, second, the prevention of outbreaks of cosmopolitan or native species of insects in the exhibition building. As it was the intention in judging certain classes of cereals to base the award not only on the physical appearance of the grain but also on germinating qualities and in certain cases by field tests to determine the purity of the strain, in the case of it being necessary to fumigate an exhibit for insect pests it was necessary to select

a fumigant which would not only kill the insect but one that would also have no effect on the physical appearance of the grain or its germinating qualities. Such being the case, an elaborate series of tests were run with different fumigants a year previous to the holding of the exhibition. The fumigant finally selected was the ethylene dichloride–carbon tetrachloride mixture used at the rate of 14 pounds per 1000 cubic feet at a temperature of 80° F. Competitive exhibits from countries other than the United States were required to enter Canada through one of the ports of importation established for the entry of nursery stock. On arrival the shipment was checked with regard to the certificate of inspection required from the exporting country, and the inspector at Regina was notified that the shipment was enroute. On arrival at the latter point a careful and thorough inspection was made of each and every exhibit. Engaged, in this work were three representatives of the Entomological Branch, two of the Division of Botany and five of the Seed Branch. Approximately five weeks was taken up in making these inspections. All samples of grain for field-growing tests were dusted with a mercury preparation (improved *Ceresan*). During the course of inspection of competitive exhibits no insect specimens were actually found but in many cases damage was noted and all such material was fumigated. As a matter of precaution all peas and beans were fumigated for weevils. Some of the display exhibits which arrived later were found badly infested with the rice weevil and the Angoumois grain moth, and these were promptly treated. A total of 580 exhibits were fumigated. In addition, the corn-on-the-cob exhibits were superheated. Those originating in the European corn borer-infested zone in the eastern United States and eastern Canada were treated before shipment. Throughout the exhibition a constant watch of the exhibits was kept and it is gratifying to note that as a result of the precautions taken no insect outbreak was recorded.

Earlier in this paper mention was made of an amendment to the Destructive Insect and Pest Act empowering the department to prohibit the export of insect pests or plant disease or vegetable matter infested with such pests and diseases and also to inspect and certify export shipments to meet the requirements of importing countries. During the last 10 years countries throughout the world have been taking precautions to prevent the importation of plants or plant products infested with pests or diseases, and to require that importations of certain commodities be accompanied by a sanitary certificate or a certificate of health. These requirements have resulted in a very great increase in the work of inspection services generally, and Canada has had to fulfill her part. As an example it might be mentioned that in 1920 a total of 48 certificates was issued for plants and tree seeds forwarded to one country, whereas for the past year approximately 5000 sanitary certificates were issued for plants, tree seeds, fresh fruits, corn, onions, wheat and other products forwarded to 39 countries. The majority of countries require a special type of sanitary certificate to accompany shipments. This results in a multitudinous number of forms often in one or more languages and makes it extremely difficult for the inspection service of the exporting country to comply with the various requirements. The various members of the

British Commonwealth have all required different types of certificates, but as the result of a resolution passed some little time ago by the delegates to the Imperial Bureau of Mycology, efforts have been made to adopt a uniform standard certificate of health for plants and plant products throughout the British Empire. Great progress has been made in this regard and it is anticipated that a uniform certificate will be adopted shortly.

The apple maggot has been the cause of considerable concern to the eastern half of the continent, as many countries are exercised over the possibility of this insect being introduced on shipments of infested fruit. In order to safeguard the export trade in apples, plans were made some years ago to inspect apples in the orchard before harvest to determine the presence or absence of the apple maggot. In October 1932, Regulation No. I (Export) was passed, which prohibited the export of fresh apples to countries other than the United States unless a certificate of inspection was issued. In 1933 a Federal Apple Maggot Advisory Committee was formed. The personnel of the committee consists of three representatives of the federal Department of Agriculture and two representatives from each of the apple-exporting provinces. In addition, the various provinces have formed provincial Apple Maggot Control Boards, responsible for the administration of the provincial regulations dealing with the control of the insect. Three of the four provinces have compulsory control measures and in the fourth voluntary cooperative control campaigns have been carried on from year to year. In late summer the various provincial boards supply the federal department with a list of orchardists who have complied with the control regulations and who desire to export fruit. Arrangements are then made for the examination of the orchard before harvesting, and only those varieties found free from infestation may be shipped. The fruit-grading inspectors are advised from day to day of the results of the orchard inspections and the fruit is again examined at time of packing. Careful records are kept of the movement of the fruit from the time it leaves the packing house until it leaves the country, and if everything is in order a certificate is issued to the Collector of Customs at the port of export in Canada.

It may be of interest to report that at the present time the federal department is installing vacuum-fumigation equipment in the inspection station at Montreal. The equipment consists of a rectangular treating tank 20 feet long, 9 feet wide and 6 feet 6 inches high, and also a small experimental tank of approximately 28 cubic feet. Provision is being made for making use of the following gases: liquid HCN, ethylene oxide and carbon dioxide, carbon bisulfide and carbon dioxide in combination, and formaldehyde. In addition, provision is made for live-steam and dry heat. Although further research is necessary in connection with vacuum fumigation, it is anticipated that as a result of this installation Canada will be in a better position to deal with infestations of insect pests found in imported products.—3-17-36.

MORE THAN five million *Ribes* bushes were eradicated in Wisconsin alone during the month of June.

COOPERATION OF OFFICIALS OF THE KANSAS PORT OF ENTRY

IN ASSISTING THE KANSAS ENTOMOLOGICAL COMMISSION TO ENFORCE REGULATORY MEASURES

GEORGE A. DEAN, *Kansas State College, Manhattan*

In 1933 there was enacted by the Kansas legislature an act relating to transportation by motor vehicles over the public highways of Kansas, which act provided for the establishment of registration stations of ports of entry into the state of Kansas upon certain main highways entering the state, through which every such motor carrier of passengers, or property for compensation shall enter the state, register, be inspected and secure permission and authority to proceed into or across the state upon its public highways. No motor vehicle, as defined in chapter 229 of the Laws of Kansas, 1933, shall be allowed to proceed into the state of Kansas upon the highways thereof, under any circumstances unless: "(a) The same shall be found by the inspector in charge of such registration station to be safe and roadworthy condition, duly and properly equipped with all light, brakes and other equipment and appliances required by law of this state in the interests of the safety and convenience of the public: and (b) duly licensed and carry the license tags required by the state of Kansas or some foreign state."

In section 2 of the above act there is created a board to be known as the Port of Entry Board, which shall be composed of the director of highways, the chairman of the corporation commission and the director of the Kansas State Department of Inspections and Registration. The said Board is invested with power to make all needful rules and regulations to secure proper and efficient enforcement of this act and the other laws of the state of Kansas in relation to motor carriers of passengers and property for hire.

The Port of Entry Board shall designate a sufficient number of the main highways entering the state reasonably to meet the needs and requirements of persons, firms and corporations operating motor vehicles for the transportation of passengers and property for compensation who enter this state from points beyond its boundaries and shall establish on each of said designated highways a registration office or Port of Entry where inspections and registration service shall be maintained.

The Kansas State Entomological Commission, which is in charge of all state and regulatory work pertaining to the suppression and control of dangerous insect pests and plant diseases, has had the full cooperation of the Port of Entry officials in the enforcement of the alfalfa weevil quarantine, and in the prevention of the transportation of nursery stock and honeybees into the state which had not been inspected and certified as required by the Kansas law. In fact, without the splendid cooperation of the Port of Entry officials it would have been impossible for the Kansas

State Entomological Commission, with the limited funds available, to have enforced the alfalfa weevil quarantine which was promulgated during the winter months of 1934 and 1935 to prevent the shipment of alfalfa hay from Nebraska into Kansas in violation of the Kansas alfalfa weevil quarantine.

The cooperation of the Port of Entry officials demonstrates in an admirable manner how one state organization may assist another in the enforcement of some of the state regulatory work. Even if sufficient funds had been available in the funds allotted to the Kansas State Entomological Commission, it would not have been possible to have enforced the alfalfa weevil quarantine to prevent the transportation of alfalfa from Nebraska into Kansas, as was done with the cooperation of the Port of Entry officials. In less than 24 hours after the alfalfa weevil quarantine went into effect, the agents in charge of the ports of entry along the northern border of Kansas were enforcing the quarantine.—3-17-36.

RECENT WORK IN CONTROL OF GYPSY MOTH AND BROWN-TAIL MOTH

A. F. BURGESS, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Gypsy moth.—In August 1933, emergency funds were authorized under the National Recovery Act to supplement the regular work of gypsy moth control, particularly in the barrier zone in New England and between it and the Connecticut river, and to continue the work on this insect in Pennsylvania. In December another grant of funds was released for a brown-tail moth program under the CWA.

The barrier zone, which was established about 12 years ago, embraces an area about 25 miles wide from Long Island Sound to the Canadian border. About half of this territory is in Connecticut, Massachusetts and Vermont, and the remainder in eastern New York.

Numerous colonies have been found in this area as a result of periodical scouting, and measures have been applied to bring about their extermination. A substantial amount of work of this type has been done by the conservation department of New York in that part of the zone in New York state, and in some areas west of the Hudson river, and scouting has been carried on during the past 10 years in most of the other counties of the state.

At the present time no infestation is known to occur in New York west of the Hudson river and the work that has been done in the barrier zone has prevented continuous spread of the insect toward the west. In the northern part of the zone in New York state and in those portions of the zone in Vermont, Massachusetts and Connecticut extensive work has been done annually by the Bureau of Entomology and Plant Quarantine, and this has been largely responsible for preventing a general spread of the insect beyond New England.

The large area in northern New Jersey, covering more than 400 square miles, that was found infested in 1920, was thoroughly inspected and

treated, and at the end of about 10 years no infestation could be found. A few egg clusters were discovered on the northern rim of the infested area in 1933, and control work and clean-up operations have been carried on there, principally by the state department of agriculture.

An infestation was found in Pennsylvania in 1932, and in the summer of 1934 an infested area was found in the Bronx in New York City. It is believed that neither of these infestations resulted from natural spread of the insect, although their sources have not been determined. Another small area near Roslyn, Long Island, is infested but this has been controlled and the infestation reduced by the state conservation department.

Although hundreds of small infestations in the barrier zone had been cleaned up, it was apparent that the danger of reinfestation was constantly increasing, particularly in woodland immediately eastward, and the emergency funds that were made available by the PWA in August 1933 were urgently needed to determine the extent of this danger and to apply remedial measures.

The work in the territory immediately east of the barrier zone during the winter of 1933–34 resulted in the discovery of a large number of rather small infested areas, principally in woodland. These infestations were treated with the aid of crews from CCC camps. These crews consisted of about 20 men each in 18 CCC camps in Vermont, Massachusetts and Connecticut, under the supervision of trained gypsy moth foremen, and directed by the Greenfield office of the Bureau of Entomology and Plant Quarantine. In Massachusetts, work was also done by local workers chiefly in the residential sections and along roadsides.

In Pennsylvania the emergency funds made it possible to carry on more intensive work in the area of worst infestation and to scout beyond this area to determine the extent of the territory infested. The state departments of agriculture and of forests and waters cooperated with the federal government in this work. On July 1, 1934, the outside limits of the infested area enclosed 470 square miles, while the territory under state quarantine, which is based on township lines, aggregated 880 square miles.

Throughout the fiscal year 1934, work was carried on in 246 townships, *viz.*, Connecticut 51, Massachusetts 43, New York 5, Vermont 90, and Pennsylvania 57; and more than 123,000 properties were examined and the infestations treated. Over 1,564,097 acres were scouted, 1751 acres thinned, 11,571 acres sprayed, 74,000 trees burlapped and patrolled, 300,000 feet of temporary fences erected to shut off sprayed areas, and more than 3000 persons almost continuously employed.

At the end of the fiscal year, when NRA funds were exhausted, the emergency force which had been trained to carry on this work was dropped. During the past year, with the small regular force remaining, work on a greatly reduced scale was carried on in the barrier zone and in Pennsylvania, and similar work was done by the New York State Conservation Department in the New York portion of the zone and on Long Island. Material assistance was received from the state of Pennsylvania, as a result of the appropriation of additional state funds for

gypsy moth work to the Pennsylvania Department of Agriculture. A gypsy moth clean-up project financed from relief funds was set up in Lackawanna and Luzerne counties, where the worst infestations are located, and men were supplied for rough clean-up work and spraying. The assignment of these men was somewhat intermittent, but this arrangement made it possible to perform on this project a large amount of necessary work which otherwise would have been impossible.

In the barrier zone the work done during the winter of 1934–35 was confined largely to the southern part of Berkshire county, Mass., and the northern part of Litchfield county, Conn. During this time 53,071 acres of woodland were scouted and 373 miles of roadside growth examined. A total of 57 infested areas were located and 11,555 egg clusters were treated. During June 1935 a total of 3547 acres of woodland were sprayed and burlaps applied to the trees in the most heavily infested areas. In preparation for the spraying work in these sections 25 miles of

Table 1.—Scope of special gypsy moth surveys, January to May 1934.

State	Number of Counties	Number of Towns or Boroughs
New York	6	72
Pennsylvania	35	309
New Jersey	10	153
Delaware	1	35
Maryland	1	3
Ohio	12	24
Total	*65*	*596*

barbed wire was used to enclose areas where spraying was to be done, to prevent animals from grazing. In the territory between the barrier zone and the Connecticut river the work was continued by CCC men and the infestation materially reduced in many places.

In the New York section of the barrier zone the scouting was done by the state conservation department. Portions of Essex, Warren, Ulster and Broome counties were also scouted, these being west of the barrier zone, but no infestations were found. In the barrier zone small infestations were found in the townships of Austerlitz and Hillsdale, and somewhat heavier infestations in Dutchess county, all of which were treated. Small infestations were found in Nassau county, in Oyster Bay and North Hampstead townships on Long Island. A rather heavy infestation was found in the Bronx, 12,000 egg clusters being found and treated.

All the infested areas in New York were sprayed by the Conservation Department during June 1935, the Bureau of Entomology and Plant Quarantine cooperating by furnishing six spraying machines and a part of the insecticides used. In New Jersey the Bureau cooperated with the state in scouting and furnished the sprayers.

During the week beginning January 21, 1934, a number of federal employees were assigned to special survey work in New York, New Jersey and Pennsylvania, in territory not known to be infested by gypsy moth. These men examined such places as tourist camps, parking spaces, recreation centers, railroad and bus terminals, cemeteries and estates to which nursery stock might have been moved. In New York this work

was performed entirely by federal men, in New Jersey assistance was furnished by the state, in Pennsylvania the federal work was confined to a considerable area extending around the present known infested section, while state nursery inspectors made similar surveys in the remainder of the state. Similar work was performed by the state inspectors in Ohio. After the completion of this work in New York and New Jersey, federal employees were able to perform a limited amount of the same type of work in the northern parts of Delaware and Maryland. The scope of these surveys is indicated in table 1.

The survey by the federal force was completed during the week ending April 27, and that by the employees of the state of Pennsylvania during the week ending May 11. No gypsy moth infestations were found as a result of this work.

Before the end of the fiscal year 1935 heavy defoliation in territory east of the Connecticut river seemed inevitable. Accordingly, at the suggestion of some of the state foresters the gypsy moth work of CCC camps was extended to this territory in the fall of 1935. The defoliation during July 1935 was the most severe that has ever been recorded, more than 500,000 acres being partially to completely stripped in New England. Large areas of woodland in the Connecticut valley were completely denuded, but only a few west of the river. Without doubt the work done during the two previous seasons prevented wholesale defoliation in many townships.

Early in August allotments by the WPA, amounting to $2,800,000 were made for gypsy moth work. These funds were allocated to the New England states, New York, New Jersey and Pennsylvania, nine states in all, and the personnel allotted by counties where the work was to be done. The program contemplated the scouting of territory on each side of the quarantine line in Maine and the cleaning-up of infestations found, similar work in the northern and western counties of New Hampshire and throughout Vermont, in the territory west of Worcester county, Mass., in Connecticut, except Windham county, and in Washington county, R. I. Work was also planned for the part of the barrier zone in New York state in cooperation with the conservation department, and in northern New Jersey and Pennsylvania, together with special scouting of surrounding territory in these states.

Since 90 per cent of the employees had to be taken from relief rolls through the National Reemployment Service, it was impossible to reemploy many of the men who had become skilled in gypsy moth work, because they were not on relief rolls. Furthermore, it was necessary to lay out the work within reasonable traveling distance from the towns where the employees lived. Furthermore, since no funds in this large allotment were made available for supervision, it became necessary to use the men available under the regular gypsy moth organization for this purpose, and to obtain as much help as possible in each state. Excellent cooperation has been secured with the states concerned, and every effort has been made by them to contribute to the success of this project.

In New Hampshire, Vermont, Massachusetts and Connecticut, gypsy moth assignments have been made from CCC camps and the work has

been adjusted to prevent duplication of effort. At the present time gypsy moth work is being conducted from 43 camps, and nine of them are used almost exclusively for this work.

This work developed slowly for the reasons mentioned above, and because transportation was not readily available to handle the greatly increased force of untrained men. On November 30, work had been taken up in 165 townships as follows: Connecticut 32, Maine 14, Massachusetts 33, New Hampshire 5, New Jersey 7, New York 3, Pennsylvania 29, and Vermont 42; and 2856 persons were employed on regular or WPA rolls. A total of 125,903 acres had been scouted and 1745 acres thinned and cleaned and slash burned. Most of this work was in woodland areas. Small infestations were found in Addison and Columbia Falls, Me., just outside of the quarantined area; in Danby and Essex, in northern Vermont; and in Greene, Sterling and Foster, Pa., and many infested areas have been discovered and are being treated within the area known to be infested. No infestation has been found in New Jersey.

The work of the crews from CCC camps in protecting the barrier zone has caused a marked reduction in infestations in many localities, and in some areas has prevented defoliation and has had a marked effect on deterring the spread of the insect.

Brown-tail moth.—On December 1, 1933, a federal brown-tail moth project was approved by the CWA, covering Maine, New Hampshire, Vermont and Massachusetts, and authorizing an expenditure of $870,850. When this project was discontinued on February 15, 1934, 65 per cent of the work was completed, 58 per cent of the funds were expended, and an average of 4506 men had been employed.

The infestations, particularly in Maine and New Hampshire, were extraordinarily heavy, and widespread defoliation and spread of the pest seemed inevitable unless control measures were applied. At the close of the work, 183,364 preferred-host trees, most of them of no economic importance, had been destroyed, and more than 19 million winter webs of the insect had been cut and burned. After the work was closed thousands of additional webs were destroyed by state workers. The extremely cold winter of 1933–34 caused heavy mortality of the moth in some localities, but this combined with the wholesale destruction of webs did not prevent a heavy infestation the following year. The records for 1934–35 are incomplete, but more than 1,790,000 webs were cut and burned in the infested area.

In August, 1935, $970,000 was allotted for a WPA project on this insect, to be expended for scouting and clean-up work in all the New England states. Although no brown-tail moth infestation is now known to exist in Connecticut and Rhode Island, a limited amount of work was planned in these states, particularly in sections adjoining Massachusetts, to determine whether the insect is now present. In connection with this work an effort is being made, in these sections where the brown-tail moth persists most continuously, to cut and burn favored food plants of the brown-tail moth, particularly such worthless species as neglected apple trees and wild cherry trees, in order to limit the food supply of this insect and prevent recurring infestation.

The same difficulties that have been mentioned in connection with the gypsy moth project were common to this one.

Work was not fairly under way until most of the deciduous foliage had fallen in October. On November 30, 1000 men were working and favored food plants had been cut and burned on 3547 acres. By the middle of December more than 600,000 webs had been cut and destroyed.

The emergency funds that have been available since August 1933 have made possible the employment of large numbers of men, and the accomplishment of much desirable work. Many gypsy moth and brown-tail moth infestations have been greatly reduced in intensity, and thereby prevented from acting as centers for local dispersion, and the danger of westward spread decreased. Moreover, many of the most dangerous infestations have been located for follow-up work, if funds become available.—3-17-36.

JAPANESE BEETLE IN THE MIDDLE WEST

J. Carl Dawson, *State of Missouri, Department of Agriculture, Jefferson City*

During the last few years a number of small isolated infestations of Japanese beetle have been discovered in several cities and towns west of the western border of the federally quarantined area. Of these, the one in St. Louis city is about 850 miles from the generally infested area, which represents the longest distance that this insect is known to have been transported on this continent.

These small infested areas represent nuclei, from which the infestation may grow and in time coalesce, thereby producing a large infested area in which we may expect tremendous losses, due to damage to plant life. With this in mind, every effort has been made in St. Louis city to reduce and suppress the infestation and to prevent its spread.

On June 19, 1934, the first beetles were officially taken in St. Louis, when five beetles were taken from traps or caught on rose bushes. It immediately become evident that the 800 traps assigned to St. Louis were not sufficient. Additional traps were obtained, until a total of 2600 was reached. The last 1000 of these traps, however, did not arrive until about the middle of July.

As beetles were caught, trap concentrations were made, so that the infested area was located. Traps which remained in a location for several weeks without catching any beetles were moved into other sections of the city, so that in this manner it was possible to trap the entire city area.

Maximum captures were made in the early part of July 1934, with the highest day's catch occurring July 6, when 220 beetles were taken. By the middle of August the beetles had apparently disappeared, and on August 21 trapping operations were discontinued. A total of 1351 beetles had been trapped in a more or less contiguous area of about 1200 acres, in a section of the city characterized by well-kept and well-watered lawns, in which many roses, grapes and other favored host plants are to be found. This area is almost entirely residential, and consequently there

are but few commercial establishments likely in any way to spread the infestation.

In an effort to prevent artificial dissemination of the insect, a state quarantine was promulgated which provided that no nursery, ornamental or greenhouse stock, or other plants, plant roots, or sand, soil, earth, peat, compost or manure could be transported from the infested area to any part outside thereof, either to or through any other part of the City of St. Louis or the State of Missouri, except under special permit issued by the State Department of Agriculture. All residents of the area were notified of the quarantine during both the fall and spring season, and a deputy plant officer regularly scouted the area for any possible violations either through the movement of plant material with soil or the movement of soil or other regulated materials in any form whatsoever.

Because of the great distance from this small infestation to the area of general infestation, and because of its serious threat to midwestern agriculture it was considered advisable that the best soil treatment practices be put into effect. Due to delay in obtaining the necessary funds, however, it was not possible to start this work until September 26, 1934. Between this date and November 8, application of approximately 225 tons of arsenate of lead, at the rate of 1000 pounds per acre, was made to 450 exposed acres in a total area of about 1350 acres, or approximately 235 city blocks. Labor was supplied by the Missouri Relief and Reconstruction Commission, with the State Department of Agriculture, the federal Bureau of Entomology and Plant Quarantine, and the City of St. Louis cooperating, by loaning equipment and supplies and supplying funds for other necessary expenditures.

During the following year (1935) 10,000 more efficient new-type traps, in which the bait container consisted of a circular perforated cylinder in the center of the baffle, were sent to St. Louis to be used in place of the 2600 old-type traps, originally built for the use of bran-mash bait.

Trap setting in 1935 began on May 22, and on June 22 the first beetle was captured. Emergence was apparently delayed, due to the unusually backward, cold, wet spring season. Maximum captures were made between July 5 and July 17, inclusive, with the highest day's catch occurring on July 8, when 134 beetles were taken. By August 10 the beetles had apparently almost disappeared. On August 17 the last beetle was captured, and trapping operations were discontinued on September 2.

With the large number of traps at hand it was possible to place at least one trap in every city block within the municipal limits in which there was vegetation upon which the beetle might feed or soil in which the beetle might lay eggs. As beetles were captured in blocks in which they had not previously been found, trap concentrations were made.

Heavy concentrations of traps in the area, where 1351 beetles were caught in 1934, were able to catch only 904 of the insects in 1935. This is a reduction of one-third in an area where a heavy increase in population would be expected had not the treating and trapping projects been placed into effect.

As much as a 50 per cent reduction in the number of beetles captured

in some of the heavily infested blocks was noted. A total of 1232 beetles was captured in the entire city, which represents a total reduction of 119 beetles under the preceding year. Two important centers of infestation of 178 and 101 beetles respectively were located outside of the area treated in 1934. One of these areas was partially quarantined the preceding year and includes two blocks which were treated with arsenate of lead. The other center is approximately a mile distant from the originally treated area. With the exception of three scattered isolated blocks, in which one-beetle finds were made, all infested areas were treated. Between August 8 and September 7 approximately 31½ tons of arsenate of lead were applied to approximately 63 exposed acres, which included all of the more important infested blocks. In an effort to cover the new infested blocks more thoroughly and to include a reasonable margin of safety, an additional 33.8 exposed acres were treated between September 26 and October 8, and 17 tons of lead were applied. A total of approximately 48 tons of arsenate of lead was applied to a total of 97.3 exposed acres in 1935, covering a total city area of about 290 acres, or approximately 50 blocks. Combining the figures on the treating of both 1934 and 1935, we find that a total of approximately 273 tons of arsenate of lead has been applied to 547 exposed soil acres, covering a total city area of 1640 acres, or approximately 285 city blocks.

The infested area under state quarantine has been slightly extended to include the new centers of infestation, and enforcement of the quarantine is being continued on the same basis as in 1934.

Throughout the duration of this work, close cooperation has been maintained with all the governmental agencies involved.

The City of St. Louis has assisted by granting necessary permits, loaning equipment, and by making miscellaneous purchases from a fund of $5000 set aside for such a purpose in the summer of 1934. Those residing in the infested area have also shown a fine spirit of cooperation. Early in 1935 a brief bulletin explaining the purpose of this work was distributed throughout the infested area by the state department, and was of value in creating a better understanding among the property holders involved. During the past fall, all the traps have been reconditioned and repainted under a WPA project. It is planned to continue the trapping program throughout the summer of 1936, with the expectation that the treating work will also be continued if it be necessary. Every effort is being continued to suppress the infestation and to minimize future possibility of further increase and spread.

Results of this suppressive work to date are encouraging, indicating the possibility that the invasion by this pest into the agricultural area of the middle west may be long deferred.—5-19-36.

CUT FLOWERS, greenhouse plants, and decorative greens moving in interstate commerce were brought within the provisions of certification requirements in Colorado, under Proclamation No. 1 issued by the state entomologist, effective June 30, following the recommendation of growers in the state. "There have been no serious problems in the industryi n this state arising from disease or pest importations" the announcement states, "and growers want the regulation as insurance against possible trouble."

THE CHINCH BUG SITUATION IN IOWA[1]

C. J. DRAKE and G. C. DECKER, *Iowa State College, Ames*

In the fall of 1935, for the fourth consecutive year, the chinch bug again entered hibernation in alarming numbers in Iowa. Favorable weather and other biotic conditions during the winter, spring and early summer would be cause to expect extensive crop damage in about 40 counties in 1936.

Although Iowa is not usually regarded as a chinch bug state, it is interesting to note that this insect pest has been recorded as damaging

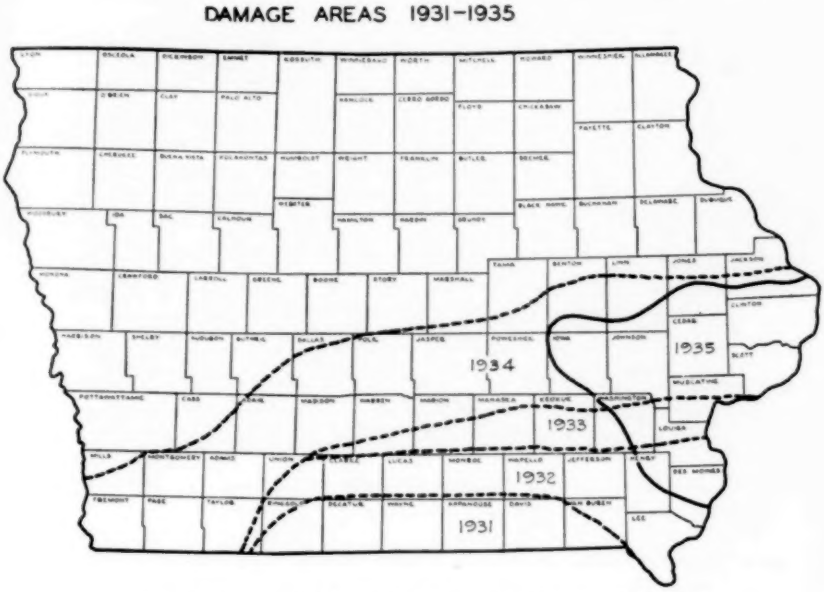

Fig. 1.—Areas of chinch bug damage in Iowa, 1931–35.

cereal crops in 44 of 89 years since it was first reported in Linn county in 1846. According to published records, major outbreaks occurred in 1860–65, 1871–75, 1879–82, 1886–88, 1894–96, 1898–1902, and 1931 to date. Several minor infestations were reported during some of the intervening years. During these years only 10 counties in the northwestern section of the state have escaped serious invasion by the chinch bug. The outbreak of 1886–88 and the present one have been the most widespread and have resulted in the heaviest losses.

The present outbreak had its beginning in 1931 in six counties (Ringgold to Van Buren) in the southernmost part of Iowa. The infestation built up and spread very rapidly and, as a result the infested area included 16 counties in 1932 and 22 counties in 1933. During the summers

[1] Journal paper J-317 of the Iowa Agricultural Experiment Station, Ames. Project 420.

of 1933 and 1934 there were two complete and a partial third generation of chinch bugs. The fall survey of 1933 showed that the bugs had entered hibernation in large numbers in 40 counties and in moderate numbers in 10 additional counties. Mortality during the winter of 1933–1934 was practically negligible.

About the middle of April 1934, the chinch bugs swarmed into the small grain fields in countless numbers and many fields of spring wheat and spring barley were totally destroyed by the adults before the eggs

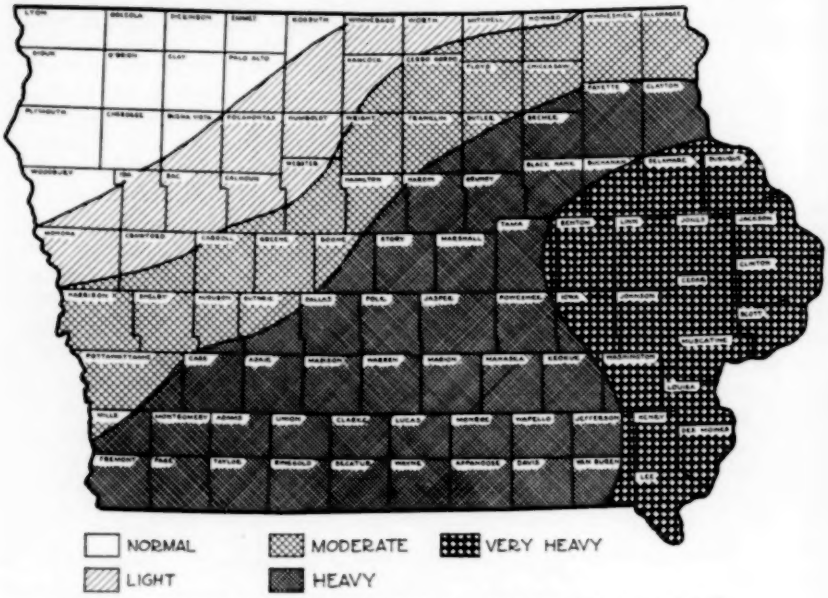

Fig. 2.—Areas of chinch bug infestation in Iowa, November 1934.

had started to hatch. In field after field the population ran from 50 to more than 200 bugs per stool of winter wheat and rye. Almost all of the barley fields were wiped out by the bugs before the plants were 6 inches tall. The migration from wheat and rye fields began on June 1 and by the middle of the month practically all small-grain fields in the heavily infested area were in a dead or dying condition and migration was well advanced. Many of the nymphs were in the first, second and third instars and some eggs had not yet hatched. The destruction of small grain by the bugs and the drought was so complete that less than 5 per cent of the fields were harvested in many counties. The bugs developed very rapidly and by July 1 the newly emerged adults were beginning to lay eggs for the second generation. In the south-central part of the state the drought became so severe in July and August that even the chinch bugs were adversely affected. Millions of bugs died of starvation and the population in this area was materially reduced. In the central and eastern

portions of the state where there was more rain and where the corn and late-summer grasses had made considerable growth, the bugs increased abundantly. In Clinton county alone more than 7000 gallons of creosote were used in August to protect corn from second-generation bugs which were migrating from the old stubble fields after the summer grasses had been destroyed. In many counties a partial third brood appeared in September, but a considerable portion of this brood failed to reach maturity before killing frosts destroyed the available food supply.

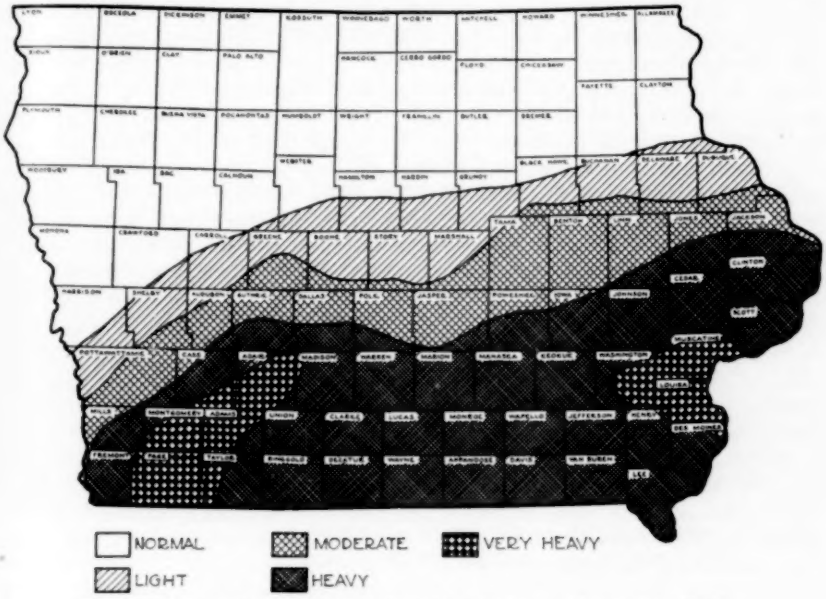

Fig. 3.—Areas of chinch bug infestation in Iowa, November 1935.

Spring, summer and fall flights in 1934, as well as during two preceding years, took place during periods when weather conditions were extremely favorable for extensive and sustained flights. This resulted in a very wide and a rather uniform extension of the infested area. In the fall of 1934 the bugs entered hibernating quarters in unbelievable numbers in 60 counties and moderately large numbers in 23 additional counties. Winter mortality, which was considerably higher than had heretofore been reported, greatly reduced the population throughout most of the infested area. The mortality varied from 20 to 35 per cent in the southeastern counties to over 70 per cent in most of the central and western counties. In some counties the winter mortality was so high that the population was reduced below the danger point. In most of the eastern counties, however, the population was still threatening in the spring. The spring migration was greatly delayed because of unseasonably cold and wet weather. As late as May 20 many bugs were still in their winter

quarters and many others were "grounded" in pastures and meadows until weather conditions would permit the continuation of flights to small-grain fields. As rains and cool weather delayed egg-laying until the last week in May, no nymphs were observed in the field until June 14. Contrary to the general belief and many press reports, the cool wet weather which prevailed throughout May and early June decreased the population only slightly.

Heavy rains during the month of May did not destroy very many adults and, since hatching had not started, the abnormal weather conditions had very little effect upon the spring population. Although the white fungus disease *Beauveria globulifera* Speg. could be found throughout the infested area, it did not become epidemic until the first week in June. Even then the epidemic outbreak of the disease was confined almost entirely to a limited area in the southeastern portion of the state.

Heavy rains which fell almost daily during the last two weeks of June destroyed the nymphs almost as fast as they hatched. Cessation of the rains about July 1 permitted the bugs hatching after that date to survive. In some areas the late hatchings were large enough to produce a population capable of doing serious damage to the grain, and paper fences or creosote barriers were constructed on many farms. In all, over 300 miles of fences and barriers were built in Clinton, Scott, Linn, Cedar, Muscatine, Louisa and Johnson counties in 1935.

Early maturing adults of the first generation began egg laying about August 1. The moderately warm dry weather which prevailed during August and September was very favorable for the development of a large second generation. The heavy frosts in the fall, however, killed the corn, foxtail and other food plants before the latter part of this generation had reached the imago state, and many immature bugs died of starvation. This greatly reduced the number of bugs entering hibernation. The fall migration to winter quarters began early in September and continued until about November 1.

The present situation in Iowa, though far less dangerous than it was a year ago, is sufficiently grave to cause considerable concern. The fall survey, which has just been completed, shows that the chinch bug population now in hibernation is slightly larger than it was in the fall of 1933 but considerably smaller than it was in the fall of 1934. The heavily infested area includes about 40 counties, seven of which have an exceedingly large population. Approximately 10 additional counties are moderately infested and eight others are included in the lightly infested area, fig. 3.

It is not possible at this time (Dec. 1935) to forecast the probable or even the possible damage to the 1936 crops, for this depends almost entirely upon weather conditions between now and next July. Biotic conditions similar to those which prevailed in 1934 would produce extensive damage in the areas of moderate, heavy and very heavy infestation and possibly spotted areas of light or moderate damage in the lightly infested zone. Another season like 1935 would probably reduce the chinch bug population to a point where damage would be limited to small areas in the seven very heavily infested counties. Since 1934 was extremely favor-

able for the bugs and 1935 extremely unfavorable for them, a recurrence of the weather conditions of either year in 1936 seems improbable. Assuming the possibility of a summer neither decidedly favorable nor unfavorable for the bugs, serious damage may be expected to occur in the 40 most heavily infested counties and spotted infestations would probably do considerable damage in the 10 moderately infested counties. Weather conditions varying in either direction from this assumed neutral or indifferent condition would correspondingly increase or decrease the probability of serious crop damage.—3-17-36.

PROGRESS IN DUTCH ELM DISEASE ERADICATION

L. H. WORTHLEY, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Eradication activities prior to 1935.—Several phases of the campaign against the Dutch elm disease in the United States have been presented in earlier reports. In introducing this progress report for 1935 it may be appropriate to review briefly those portions of the program pertaining to the establishment of eradication policies, methods, and the degree of completion of each year's program.

Before the Dutch elm disease reached the United States, European investigators had determined the causal organism, some of the factors involved in its spread, and its potential destructiveness. Upon discovery of the disease in Ohio in 1930, a policy of eradication based on this information was adopted immediately. This involved the prompt location and destruction of diseased trees, as well as fundamental research and laboratory diagnosis of this and various other elm diseases. Favorable acceptance of this policy of eradication was in sharp contrast to the skepticism prevailing in the early work against the chestnut blight.

Failure of the disease to reappear in Ohio in 1932 led to consideration of extending the search for it to other areas in 1933, and this was followed by discovery of the disease in New Jersey in June 1933. It was soon found that the disease had reached epidemic proportions in the vicinity of New York City, involving portions of New York, New Jersey and Connecticut, and the program of eradication adopted in Ohio seemed to be justified. The personnel engaged in eradication work in Ohio was therefore hurriedly transferred to New Jersey, several men were transferred from other projects in the Department of Agriculture, and additional men were obtained from the Emergency Conservation Works technical staff and CCC camps. In August an NRA allotment made it possible to employ trained scouts on the project, and later a CWA grant permitted the first field work during the winter months.

In an effort to locate as many diseased trees as possible, a program involving the systematic sampling of each elm in the suspected area was given precedence over a sanitation program, comprising the removal of dead and dying elms. Although many beetle-infested diseased trees were destroyed, it is possible that the sanitation program might have been

more effective in controlling the disease. The experience gained in these early control activities has proved valuable to the state leaders and field supervisors now directing the work.

During the winter of 1933–34 a much expanded eradication program was outlined. Continuation of systematic scouting and prompt removal of confirmed trees in the known infected zone were considered of primary importance. At that time it was also planned to assign a trained scouting force to cover territory within a radius of 60 miles from the infection center but outside the known infected zone, then included within an approximate 30-mile radius. The scouting work was to include the mapping of individual, scattered elms and groups of elms, as well as a thorough examination of several outlying areas and railroad routes. In addition to the scouting activities, an extensive sanitation program was proposed. The removal of all elms in swamp areas that could not be satisfactorily scouted and which were found to contain concentrations of diseased trees, and the destruction of worthless elms in wooded and mountainous areas were recommended, not only as being good forestry practice, but also to facilitate summer scouting. It was cited that most of this type of work could be performed by CCC and relief workers under trained supervisors. The satisfactory performance of a number of CCC scout crews working from established camps indicated the adaptability of this organization for work in undeveloped sections.

In carrying out this program, the winter CWA work was modified to focus attention on diseased elms that might produce beetles before the trees could be located by summer scouting. This work was continued until May, when exhaustion of funds forced it to be temporarily abandoned. Lack of funds also prevented the starting of systematic scouting until late in June. Owing to the late start, the diseased area was covered only about half as thoroughly as planned. No scouting was performed in sections contiguous to the known infested area, and systematic scouting could not be extended to the outlying areas or along railroads. Late in the summer ECW technicians located two new infections, one at Indianapolis, Ind., and the other at Norfolk, Va., and two additional confirmed trees were found in the Cleveland infected zone. Scouts employed by the State of Connecticut located a diseased tree at Old Lyme, a point about 45 miles east of the known limits of the major infected zone. At the end of 1934 there had been found in the tri-state area 56 diseased trees in Connecticut, 5117 in New Jersey, and 2502 in New York. The diseased trees were removed rather promptly in New York and Connecticut, but in New Jersey about one-third of the confirmed trees were still standing at the end of the summer. A good start was made in tagging dead and dying elms in the major infected territory for later removal by sanitation crews, and at the end of the year these crews were being organized, although their work did not start until 1935.

Eradication activities in 1935.—At the beginning of 1935 the known infected zone included an area within 40 miles of New York City and two points within the 50-mile limit. A survey of the results of the previous year's activities indicated an urgent need for the scheduled expansion of the eradication force. The necessity for increased personnel was em-

phasized by the extension in the infected area, the increase from 830 to 7600 in the number of known infected trees in the major diseased zone, and the newly discovered infections in Indianapolis, Norfolk and Old Lyme. The fact that where eradication had been thorough in 1933 more satisfactory conditions were found in 1934 inspired confidence in the success of the program outlined for future years. The failure to complete the program in 1934 only emphasized the fact that the 1935 campaign would be more difficult and costly.

During the first four months of the year an excellent start was made in the sanitation work. More than 400,000 dead and dying elms were removed before exhaustion of the current allotment of PWA funds forced discontinuance of the work. About 1000 men were employed on this project, and they were supplemented by a few regular field supervisors. It soon became necessary to revise the original estimates of the number of devitalized elms in swamps and undeveloped areas. As a partial compensation, well-organized crews and a close check on their efficiency resulted in the removal of about three times as many trees per man-day as had been anticipated. The fact that most of the trees not included in the early estimates were small elms concentrated in swamps also facilitated their removal. Dead and dying trees were removed from about two-thirds of the known infected zone. Justification for this procedure was amply demonstrated when laboratory cultures showed that from three to 30 per cent of these trees may contain the Dutch elm disease fungus.

In preparation for an early and effective start of systematic scouting, approximately 1000 men, some newly referred from the National Reemployment Service and some members of eradication crews, were given preliminary adaptability tests. Men meeting the requirements were placed in the scout schools. However, when the new allotment of emergency relief funds under the Works Progress Administration became available on June 3, it was stipulated that 90 per cent of the personnel must be taken from relief rolls, and most of the qualified men in training had to be dropped. A new force was organized as rapidly as possible, but by July 13 only 800 scouts were in the field. The task of obtaining from the relief rolls men at all adapted to the work and training them for systematic scouting required approximately one month. By the third week in August 2000 scouts were at work. Unfortunately, however, their activities did not begin until too late to be most effective. With inexperienced scouts the rate of coverage was greatly reduced, and it was necessary to double the force and extend the scouting a month beyond the normal date for its discontinuance. The first week in August scouting was started in 12 outlying areas, and by the middle of the month crews of four to 16 men obtained through the National Reemployment Service were at work in these communities. In September this work was supplemented by a small amount of railroad scouting in adjacent areas. Late in the season a waiver of the 90 per cent relief requirements on 500 men made it possible to reemploy for a short time some of the scouts that were laid off in May and to hire qualified non-relief men for the scouting in outside areas.

During the summer practically all the known infected zone was systematically scouted once, about half of it twice, and a few areas received three surveys. About half of the 10-mile protective zone was scouted once. The infected area in New York and New Jersey was extended for a radius of about 10 miles. After the scouting season, a number of sample plots were established near the outer boundary of the 10-mile zone. Dutch elm disease infection was found in three of these plots located in swamp areas having high concentrations of elms, which were not included in the summer scouting. These late finds extended the diseased area uniformly to the 50-mile limit, except in the southern New Jersey pine-barren area.

The railroad scouting revealed a new spot of infection about 50 miles west of Baltimore near the Baltimore & Ohio transfer center at Brunswick, Md. A sample plot of dead and dying trees established this fall in the infected section of Cleveland also disclosed 21 diseased trees.

During 1935 specimens were collected from 36,258 suspected trees. Of these, 6440 were found, upon culturing, to be infected with the Dutch elm disease. At the end of the year, in the major infected zone, a total of 133 confirmed trees had been found in Connecticut, 9177 in New Jersey and 4766 in New York. Infected trees found to date in outlying areas are as follows: Baltimore 1, Brunswick 3, Cleveland 33, Cincinnati 1, Indianapolis 14, Norfolk 4, and Old Lyme 5.

In 1935 the removal of diseased trees was kept more nearly up to date than in 1934. New York improved on its 1934 record and throughout the summer kept the number of its standing, confirmed trees at a minimum. Conditions in New Jersey were greatly improved this year and compared favorably with those in New York. Removal of infected trees has never been much of a problem in Connecticut and was, as usual, carried out promptly. State officials made all preliminary arrangements for removals while the trees were actually destroyed by federal or state crews, or on state contracts, according to the money available for the work during the different periods.

In May an application was made for the establishment of six CCC camps in the main infected zone, one in Connecticut, three in New Jersey, and two in New York. Two of these camps were set up on August 15. Three more camps started operations during September, and men from the sixth camp were placed in the field the first of December. These crews have been assigned to remove dead and dying trees and clean-cut some swamp and undeveloped areas. One camp has its own scout crews to do the tagging. In general, the type and amount of work accomplished has been satisfactory. Selection of superintendents and foremen for some of the camps from the regular Dutch elm disease eradication personnel has proved advantageous. The availability of a permanent organization with adequate supervision, with well-fed and well-clothed men, and with necessary tools and trucks, has facilitated this work. In rural and undeveloped areas the CCC workers again have proved their adaptability to Dutch elm disease eradication work.

On September 15 the supervisors who had been carried as per-diem employees on the regular departmental appropriation had to be dis-

missed. Furthermore, the waiver expired under which it had been possible to employ 500 non-relief workers, and it was necessary to drop most of these men. With the exception of 50 men, including state and district leaders and supervisors on appointment status, all the field supervisors and foremen were in the $85-per-month classification, could work only six and one-half hours a day for five days a week, and 90 per cent of them came from relief rolls.

After the scouting season closed, all forces were concentrated on sanitation work. In conjunction with summer scouting, workers in Connecticut and New York had tagged all dead and dying trees over a large portion of the infected zone. In New Jersey tagging was not begun until the elms had begun to drop their leaves. In addition to the sanitation work, several crews were assigned to eliminate all elms in certain swamp areas in the diseased zone as the only practical means of eradicating the disease in such elm concentrations. During the summer a method of treating stumps with copper sulfate to prevent sprouting was developed by the research workers.

The week ending November 30 the field force consisted of 160 two-man scout crews and 173 sanitation crews of about 15 men each, making a total of more than 2500 men, not including 800 men in CCC crews. All necessary tools and new automotive equipment were in the field on that date. The necessity, in some sections, for transporting WPA crews 30 miles to their work site cut down their accomplishment. In December an attempt was made to enlarge the field force, but referrals of qualified men from the relief agencies were so delayed that at the end of the year only 2612 WPA workers were in the field. On January 1, 1936, the field personnel started on a 16-days-per-month, 8-hours-a-day basis. This will permit more work with less travel and with closer supervision.

At the end of 1935 a total of about 990,000 dead and dying trees and elms in swamp areas in the three states had been removed, and approximately 465,000 others had been tagged for future removal. In Connecticut all dead and dying trees in the entire work area had been tagged, and at the present rate of removal all these tagged trees should be taken out this winter. In New York the infected zone and a small portion of the 10-mile area have been completely scouted for dead and dying trees, and all tagged trees in this territory will probably be removed this winter. Because of the recently extended area in New Jersey, only about half of the infected zone has been tagged, but with an enlarged force it may be possible this winter to complete the sanitation work in most of the infected zone in this state.

Discovery of the Dutch elm disease in dead and dying trees in Cleveland made necessary a sanitation project there. Accordingly, a supervisor and scouts started tagging dead and dying trees in a 25-square-mile area in the northeastern part of Cuyahoga county and a small portion of western Lake county, within which all diseased trees thus far found in Cleveland have been located. The same general policy is being followed there as in the major infected zone. As soon as possible the force will be increased to 100 men. The State of Ohio is cooperating by furnishing two men to make contacts with property owners from whose

premises trees must be removed. Present plans do not include sanitation work at any other infected area outside of the major zone.

State expenditures for Dutch elm disease work for the 1935 calendar year amounted to $12,500 in Connecticut, $53,000 in New Jersey, and $150,000 in New York. Aid rendered by the states of New Jersey and New York was of great value during the periods of federal inactivity last summer. In June, when federal funds were lacking, New Jersey employed more than 200 men to start systematic scouting. During July, August and the first half of September, New York placed from 60 to 100 trained scouts and supervisors in the field. From September 15 to November 15, New Jersey employed 55 men to assist in tagging dead and dying trees and in supervising sanitation crews. This assistance, especially in the supervision, added materially to the efficiency of the relief.

Summary of the 1935 work and plans for 1936.—During the first four months of 1935, sanitation work was performed in about one-third of the present infected zone. Very little scouting was done during May and June, the period when scouting is most effective. During July, August and September relief scouts completed about half of the planned program. In the entire area 80 per cent as many diseased trees were found as in 1933 and 1934. In an area in New York scouted three times by trained men as many confirmed trees were found as in 1934. The removal of diseased trees was fairly prompt throughout the summer.

The sanitation work in the known diseased area may be completed this winter. Under the program planned to accomplish this, relief funds will be exhausted by about the first of April. To put the disease under immediate control and make satisfactory progress toward eradication, funds for a trained scouting force will be required. Continued use of CCC men will assist in completing the program in rural and undeveloped sections. Continuance of close cooperation with the affected states is necessary. Thorough checking of conditions in the outlying areas and railroad routes is also essential. Inasmuch as the policies and methods of eradication have been found to be sound, there is no need for alteration of present methods of procedure. Circumstances did not permit completion of the programs outlined for 1934 and 1935. A stable and trained organization of sufficient size to complete the scouting, eradication and sanitation work in 1936 should show a great advance toward the eradication of the Dutch elm disease in the United States.—3-17-36.

THE MICHIGAN STATE quarantine relating to the potato tuber moth (No. 514) was suspended on June 19, and all restrictions on the entry of potatoes from the affected states withdrawn until further notice.

NOTICE COMES FROM OREGON officers of enactment of a quarantine on May 6 to prevent transportation of the East Indian bean borer by prohibiting entry of flowers of the Maunaloa from the Territory of Hawaii, also the revision on March 21 of the quarantine relating to the vegetable weevil in California, adding celery to the list of host plants of the weevil.

UNDER RECENTLY PLACED regulations in Arkansas, every bundle of 100 or more sweet potato plants sold or shipped into the state must be labeled with the name of the grower and his application number.

EASTERN BRANCH

PAPER-READING SESSION, SEVENTH ANNUAL MEETING

Baltimore, Md., November 1935

TOXICITY OF ROTENONE AND PYRETHRINS, ALONE AND IN COMBINATION[1]

RICHARD H. LEPELLEY, *Kenya Colony and Protectorate, Department of Agriculture*, and W. N. SULLIVAN, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Although much work has been done on the toxicity of rotenone and of pyrethrins to various insects, comparatively little study seems to have been made of the toxicity of these poisons in combination. It has been shown by Campbell, Sullivan & Jones (*1*) that the mode of action of pyrethrins and rotenone is dissimilar against house flies, the former producing rapid paralysis and causing death or permitting complete recovery within 24 hours, and the latter acting less rapidly but causing death or permanent injury. This preliminary study was planned not only because of the general interest in the problem of the effect of these poisons in combination, but also with the thought that the information obtained might contribute to the improvement of sprays for the control of coffee insects in Kenya Colony, East Africa. The senior author (*6*) has described the use of kerosene extracts of pyrethrum for spraying hemipterous insects on coffee trees. The insects so treated are paralyzed and drop from the trees, but a sufficiently high percentage recover to make it necessary to collect and destroy the fallen insects. It seemed that this labor might be eliminated if extracts of a rotenone-bearing plant were used in combination with the pyrethrum extract.

Materials and methods.—It was decided in this preliminary study to determine the relative effectiveness against house flies of rotenone, pyrethrins, and combinations of the two in 95 per cent ethyl alcohol.

The stock solution of pyrethrins and the sample of pure rotenone used in these experiments were prepared in the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine. The solution of pyrethrins was prepared by H. L. Haller and F. B. LaForge from a commercial concentrate containing 14.5 per cent pyrethrin I and 14.7 per cent pyrethrin II (Seil's method of analysis). The solution was prepared shortly before it was used and was made to contain 5 mg. of total pyrethrins per cc. of alcohol. It was kept in a well-corked amber bottle, which was placed in a refrigerator at 42° F when not in use. The rotenone was a sample prepared by H. A. Jones in 1933. It has been kept in the dark at room temperature when not in use.

[1] This work was done at the Takoma Park, Md., laboratory of the Bureau of Entomology and Plant Quarantine while the senior author was the holder of a Commonwealth Fund Service Fellowship. The senior author desires to express his indebtedness to the Division of Control Investigations of the Bureau for facilities and privileges accorded. Acknowledgment is made to F. L. Campbell, U.S.D.A., for assistance in preparing this manuscript for publication, and to C. M. Smith and Alexander Sturges, U.S.D.A., for statistical assistance.

A turntable method, recently described by Jones, Campbell & Sullivan (*4*), was used to apply the alcoholic solutions. For the present work one slight modification had to be made in the equipment: *i.e.*, a strip of muslin was tacked in each runway of the turntable to absorb surplus solution sprayed into the cylinders and thus to prevent the solution from being dragged into the dishes of flies when the cylinders were pulled over the dishes. This precaution had not been necessary in previous work (*4*) when acetone was used as the solvent, because acetone evaporates more rapidly than alcohol.

The first tests were made to determine the concentrations of rotenone and pyrethrins that would give a range of mortality from well below to well above 50 per cent. Five concentrations of rotenone, five of pyrethrins and five of rotenone plus pyrethrins were then selected for the

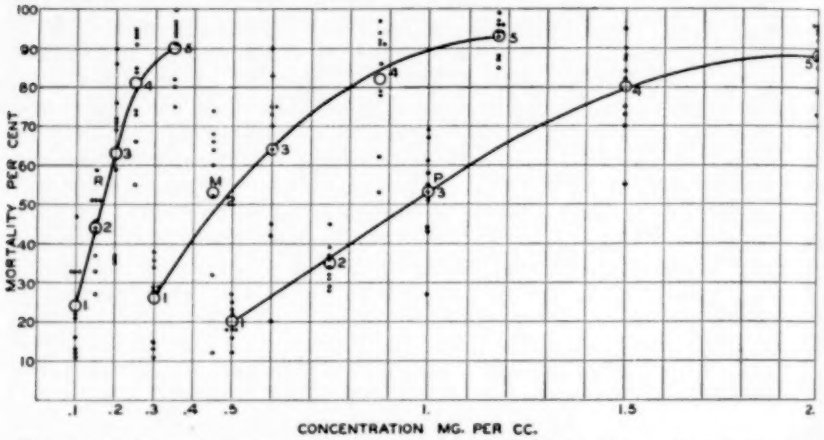

Fig. 1.—Relation between concentration of alcoholic solutions of rotenone (R), pyrethrins (P), and 50–50 mixtures of the two (M) and mean mortality of house flies three days after treatment. Concentration of

$$M_1=\frac{R_1}{2}+\frac{P_1}{2};\quad M_2=\frac{R^2}{2}+\frac{P_2}{2};$$

etc. The mean mortalities are indicated by circles; the individual observations by dots.

final tests. These 15 solutions were usually tested in duplicate together with six alcohol checks, making 36 tests per day, 100 flies per test. Two groups of tests were made differing only in the proportions of rotenone and pyrethrins in the mixtures and in the number of replications.

For the first group of tests, replicated 10 times, the concentration of rotenone plus pyrethrins was chosen as follows: if R represents a concentration of rotenone and P a concentration of pyrethrins that produce approximately the same mortality, then the concentration of the corresponding mixture was made $\frac{R}{2}+\frac{P}{2}$. This was accomplished by mixing equal volumes of solutions having concentrations R and P. The resulting solutions may be called 50:50 mixtures of the five pairs of solutions of rotenone and pyrethrins.

For the second group of tests, replicated nine times, 25–75 mixtures of the same solutions were prepared, the concentration being represented by $\frac{R}{4}+\frac{3P}{4}$.

Results.—The results of the first group of tests are shown in fig. 1 and those of the second group in fig. 2. In both figures each individual mortality count is plotted as a dot. The dots on any vertical line show the variation in mortality which occurred in the tests of the concentration represented by that line. When a certain mortality occurred more than once in tests of any one concentration, the dots were plotted closely side by side. The mean of each series of dots is represented by a circle. Smooth curves were drawn as nearly as possible through these circles.

The relative positions of curves R and P in figs. 1 and 2 show that

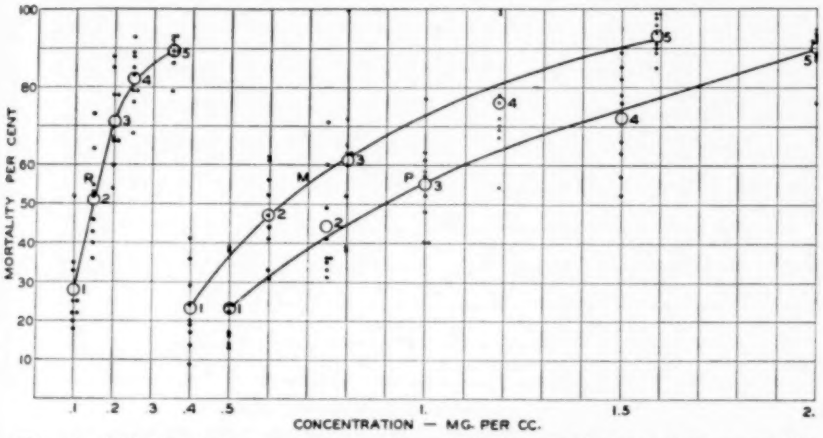

Fig. 2.—Relation between concentration of alcoholic solutions of rotenone (R) pyrethrins (P), and 25–75 mixtures of the two (M) and mean mortality of house flies three days after treatment. Concentration of

$$M_1=\frac{R_1}{4}+\frac{3P_1}{4};\quad M_2=\frac{R_2}{4}+\frac{3P_2}{4};$$

etc. The mean mortalities are indicated by circles; the individual observations by dots.

rotenone was from five to six times as effective as pyrethrins under the conditions of these tests. A visual impression of the degree of reproducibility of results may be obtained by comparing curves R or curves P in the two figures. Although determined independently of one another they are very nearly the same in shape and position.

Curves M representing the effect of the mixtures of rotenone and pyrethrins necessarily lie between curves R and P. If the effect of the components of the mixtures is approximately additive, the mean mortality represented by circle M_1 should be about the same as that represented by R_1 and P_1, M_2 should be nearly equal in mortality to R_2 and P_2, and so on. Inspection of figs. 1 and 2 shows that this is roughly true. It is therefore concluded that no striking antagonistic or synergistic effect

occurred[2] and that the two poisons are compatible in alcohol. The mortality caused by alcohol alone was negligible.

It was suggested that the best single measure of variation in one group of experiments would be the standard deviation of the observed mortalities from the mean mortalities of duplicate tests to which they belong. In the first group of tests there were 74 pairs of observations and the standard deviation from the means of these pairs was ± 6.55 per cent mortality. It might be clearer, though statistically less satisfactory, to say that the average difference between the members of the 74 pairs was 10.2 per cent mortality.

Discussion.—The relative effectiveness of pyrethrins and rotenone against house flies was previously studied by Gnadinger & Corl (*2*). The poisons were dissolved in a certain refined petroleum oil to which was

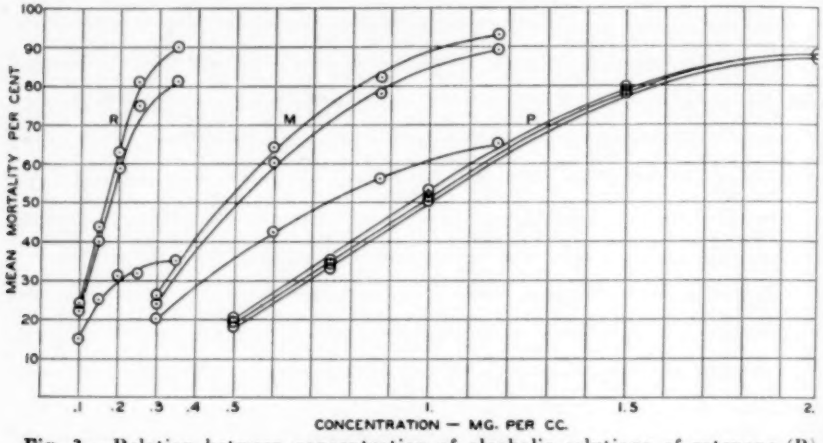

Fig. 3.—Relation between concentration of alcoholic solutions of rotenone (R) pyrethrins (P), and 50–50 mixtures of the two (M) and mean mortality of house flies one, two, and three days after treatment. The lowest curve of each group shows the mortality one day after treatment, the intermediate curve after two days, and highest curve after three days.

added a little acetone and petroleum ether. The tests were made by the well-known method of Peet & Grady. It was found that pyrethrins were somewhat more effective than rotenone. In the present tests rotenone was found to be decidedly more effective than pyrethrins. Without attempting to examine all possible reasons for the different results obtained by Gnadinger & Corl and the writers, it might be pointed out again that the 24-hour mortality count of the Peet-Grady method does not allow sufficient time for rotenone to reach the peak of its lethal effect.

[2] In this paper LePelley & Sullivan conclude that no striking antagonistic or synergistic effect was caused by interaction of the components of the mixtures. Attempts were made to determine whether the observed effects of the mixtures differed significantly from those that might be predicted if the components act additively. For this purpose a definition of expected effect was needed. The basis proposed for such a definition is the following: if solution R containing rotenone and solution P containing pyrethrins each produces independently the same mortality D, this same mortality D will be produced by any mixture of R and P, provided of course that the same volume of spray is applied in all cases. On the basis of this assumption the 50–50 mixtures appeared significantly more effective than would be expected if the components had acted additively. Although the effect of the 25:75 mixtures was generally somewhat greater than expected, the significance of the difference was doubtful.—H. H. Richardson, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

In their first group of tests the present writers made mortality counts at the end of one, two, and three days and confirmed the findings of Campbell, Sullivan & Jones (*1*), that the lethal effect of pyrethrins reaches its peak within 24 hours, whereas that of rotenone is probably not reached at the end of three days. The present writers' results are illustrated in fig. 3, in which the mean mortality after the first day is represented in each case by the lower curve, after the second day by the middle curve, and after the third day by the upper curve. The mortality of flies treated with pyrethrins was practically the same at the end of one and three

Table 1.—Results of duplicate tests against house flies of acetone extracts of *Cracca vogelii*.

Part of Plant	Concentration*	Mean Mortality in Three Days
	mg. per cc.	*per cent*
Foliage	16	85
	8	62
	4	11
	2	5
Roots	40	86
	32	79
	24	75
	16	42
Stems	40	46
	32	22
	24	15
	16	4
Rotenone standard	.20	77
	.15	51
	.10	32

* Milligrams of plant material equivalent to 1 cc. of diluted extract, or milligrams of rotenone in 1 cc. of solution.

days, whereas that of flies treated with rotenone was much greater at the end of the third day. The effect of the 50:50 mixtures was intermediate in this respect.

Gnadinger & Corl (*2*) tested one 50:50 mixture of pyrethrins and rotenone and, like the present writers, found that the lethal effect of the combination was not unlike that of the components. Apparently no extraordinary synergistic effect is produced by such mixtures, but it is still reasonable to hope that the paralyzing effect of pyrethrins and the more persistant crippling and lethal effect of rotenone might be advantageously combined in mixtures of these poisons for the control of coffee bugs in Kenya.

For the application of such mixtures in Kenya it is desirable that a cheap source, preferably a local one, of rotenone or related poisons should be available. The use of *Cracca vogelii* (*7*) for this purpose suggested itself and samples were obtained from F. B. Notley of the Department of Agriculture, Kenya. From these samples H. A. Jones, Insecticide Division, Bureau of Entomology and Plant Quarantine, prepared acetone extracts of the foliage, stems and roots, the stock extracts being made up

so that 1 cc. of the extract was equivalent to 200 mg. of the plant material. The application of the modified Durham blue color test (*5*) on these extracts indicated that the foliage might be expected to contain about 3 per cent of rotenone or similar materials giving the blue color of this test, the roots 1 per cent and the stems .5 per cent.

Time was available for only a few insecticidal tests of these extracts by the turntable method (*4*). The results, table 1, show that effectiveness of the extracts against house flies was in the order indicated by the Durham test, the foliage being most effective followed by the roots and stems. The insecticidal content of the foliage was equivalent to about 2 per cent of rotenone. Jones, Campbell & Sullivan (*3*) showed that good commercial samples of derris and cubé contain insecticidal materials equivalent to about 10 per cent rotenone. The present sample of foliage of *Cracca vogelii* was therefore about one-fifth as effective as commercial samples of derris and cubé. Of course the insecticidal value of a species of rotenone-bearing plant cannot be judged by a few tests of one sample, but the present results are encouraging because the toxic principles are located chiefly in the readily accessible leaves instead of the roots, as is usually the case in other rotenone-bearing plants.

Summary.—Alcoholic solutions of pyrethrins and of rotenone and mixtures of these solutions were tested against house flies by a turntable method. Rotenone was from five to six times as effective as pyrethrins containing pyrethrin I and II in equal proportions, when mortality counts were made at the end of three days after treatment. No striking synergistic effect was produced by 50:50 mixtures of these solutions but they appeared to be significantly more effective than expected. It was doubtful whether the 25 (rotenone):(75 pyrethrins) mixtures were more effective than expected.

As the results showed that mixtures of rotenone and pyrethrins are compatible, attention was given to sources of rotenonelike insecticides for mixing with pyrethrum extracts for the control of coffee insects in Kenya. A few tests were made of acetone extracts of the leaves, roots and stems of a sample of *Cracca vogelii* received from Kenya. The effectiveness of these parts decreased in the order named. The extract of the leaves, which contain the largest proportion of toxic materials, exerted an effect equivalent to a rotenone content in the plant material of about 2 per cent.—5-29-36.

Literature Cited

(*1*) **Campbell, F. L.,** W. N. Sullivan and H. A. Jones, 1934. Derris in fly sprays. Kerosene extracts of derris root as house fly sprays. II. Comparative tests of extracts of derris and of pyrethrum. Soap **10**(4):83, 85, 103, 105.

(*2*) **Gnadinger, C. B.** and C. S. Corl, 1932. The relative toxicity of pyrethrins and rotenone as fly spray ingredients. Jour. Econ. Ent. **25**(6):1237–40. Dec.

(*3*) **Jones, H. A.,** F. L. Campbell and W. N. Sullivan. 1935. Relation between chemical composition and insecticidal effectiveness of rotenone-bearing plants. Jour. Econ. Ent. **28**(2):285–92. Apr.

(*4*) ———— 1935. *Cracca*—a source of insecticides. A preliminary study of domestic species of devil's shoestring as sources of insecticidal materials. Soap **11**(9): 99, 101, 103, 105, 107, 109.

(*5*) **Jones, H. A.** and C. M. Smith, 1933. A color test for rotenone. Indus. Eng. Chem., Anal. Ed. 5:75–6.

(6) LePelley, R. H. 1933. Field spraying with undiluted paraffin extracts of pyrethrum against *Antestia* and *Lygus* on coffee in Kenya. Bul. Ent. Res. **24**: 1–32.

(7) Worsley, R. R. LeG. 1934. The insecticidal properties of some East African plants. I. Ann. Appl. Biol. **21**: 649–69.

THIRD GENERATION AND METHOD OF MIGRATION OF CHINCH BUG IN SOUTHWESTERN OKLAHOMA

RALPH O. SNELLING, *U. S. Department of Agriculture, Bureau of Plant Industry*[1]

Observations in the past by several investigators on the life history of the chinch bug agree that two full generations are all that occur over the entire range of this insect. However, nymphs of a third generation that failed to reach the adult stage have been reported in this country by a few entomologists as far north as southwestern Oklahoma, and a few statements have been published which hint at the possibility of more than two generations under some conditions. The observations reported here describe three full generations as observed under field conditions in southwestern Oklahoma, during the years 1930, 1932, 1933 and 1934, and under cage conditions in 1933, which was the only year that a cage was used.

Review of literature.—Dean (*1*) mentions only two generations of the chinch bug each season. Headlee & McColloch (*3*) state, "All students of the subject are agreed and all observations at this (Kansas) station thus far confirm the notion that the chinch bug produces two generations a year." McColloch & Yuasa (*7*) state, "The second brood of the chinch bug begins to reach maturity about the last of August, although the majority do not reach maturity until the last of September. These adults migrate to the grassland where they pass the winter in the clump-forming grasses." Webster (*9*) goes a little farther by saying, "Over the territory covered by the long-winged form of the chinch bug, the insect has two generations each year." Luginbill (*6*) states, "There are two generations of the chinch bug annually in the south, the same as in the north." Flint & Larrimer (*2*) and Kelly (*5*) state, "There are two generations of the chinch bug each season throughout the entire range over which it occurs in this country." Wilson (*10*) states, "Since the average length of the chinch bug life cycle is 49 days, it is possible that in Florida at ordinary temperature there are five or more generations a year." In addition he states, "In northern Florida the adult bugs hibernate or become dormant with the approach of cold weather. In the extreme southern portion of the peninsula it is probable that the adults are active during all but a few of the colder days of winter." Wilson mentions the possibility of

[1] The writer is indebted to Dr. Reginald H. Painter, Department of Entomology, Kansas State College, and Mr. W. M. Osborn, U. S. Department of Agriculture, Division of Dry Land Agriculture, Bureau of Plant Industry, for helpful suggestions in writing this paper.

Observations reported here on the life history of the chinch bug were started while the writer was employed by the Department of Entomology, Kansas Agricultural Experiment Station, and have been continued incidental to resistance investigations after employment by the Bureau of Plant Industry.

five or more generations a year in Florida but does not state that they actually occur. Horton & Satterthwait (*4*) state, "It is seen that over most of the range of the long-winged form, the chinch bug has but two full generations, and in the southern portion of its range a partial third generation annually." This third generation, they state, "appears never to develop beyond the nymph stage and not to survive the winter." Shelford (*8*) presents evidence of a third and a fourth generation of chinch bugs obtained under artificial conditions. He states, "Records of complete life histories of individuals from egg to adult are lacking in our work . . . No individual was traced through from egg to the adult condition in the experiments here reported . . . There are normally two generations of the chinch bug per season, but the number may be increased under favorable conditions." Variability of generations as deter-

Table 1.—Monthly and annual precipitation at the United States Dry Land Field Station, Lawton Okla., 1929–1934, and averages for 1916–1933.

	Precipitation in Inches						Averages	
							6 Yrs.	18 Yrs.
	1929	*1930*	*1931*	*1932*	*1933*	*1934*	*1929–1934*	*1916–1933*
Jan.	.94	.82	.82	4.26	1.01	1.17	1.5	1.29
Feb.	.8	.19	1.84	1.87	.96	2.18	1.31	.82
Mar.	3.1	.26	1.77	.21	3.3	1.46	1.68	1.69
Apr.	.01	4.08	2.14	2.16	2.46	.97	1.97	3.07
May	12.26	5.75	.93	1.19	6.27	3.48	4.98	4.18
June	1.94	2.47	1.2	7	.25	2.27	2.52	2.87
July	3.15	.57	4.75	.74	6.28	.08	2.6	2.78
Aug.	.31	.55	1.7	4.98	1.9	.77	1.7	2.39
Sept.	4.45	1.7	.05	1.23	2.68	3.49	2.26	2.61
Oct.	2.3	9.74	5.22	1.59	1.1	.97	3.49	4.29
Nov.	1.25	1.64	6.24	.08	.42	3.32	2.16	1.57
Dec.	.23	2.67	1.4	3.95	2.79	.15	1.87	1.51
Annual	30.72	30.44	28.06	29.26	29.42	20.31	28.04	29.07

mined by vigor of stock between seasons is noted, and evidence is presented which shows that a fourth generation was obtained in 1919 and 1925 under artificial conditions. The data presented by Shelford were secured during a study of other problems and he states, "These data may not be taken as demonstrating beyond any doubt that four generations of bugs occurred."

General crop and weather conditions at Lawton station.—The observations presented here were made at the United States Dry Land Field Station, located near Lawton in southwestern Oklahoma, in connection with studies on the resistance of sorghum varieties to chinch bug injury. No other extensive area in the great plains is directly comparable or similar to the one in which the Lawton station is located. The average precipitation of about 29 inches is heavy enough to warrant the general classification of the section as subhumid rather than semiarid, table 1, but the rainfall is torrential in character, and its monthly distribution is variable. The crop seasons are frequently long and hot, and more or less protracted periods of drought are common. Conditions highly favorable to the growth of tender vegetation may suddenly change to conditions that are common to arid regions where plant growth is dwarfed and stunted.

Numerous crops that serve as hosts for the chinch bug are grown throughout southwestern Oklahoma. Wheat, oats, barley, corn, sorghums, broomcorn and Johnson grass are all common to this section.

Their periods of growth are such that ample food for this insect is provided throughout the entire growing season, table 2.

The native vegetation on the station is representative of that found in southwestern Oklahoma. Little bluestem, *Andropogon scoparius* Michx., constitutes the chief plant cover. Herbaceous plants and short grasses are well interspersed. The native vegetation offers ample protection for the chinch bug during the relatively mild winter months in this section. The average annual minimum temperature is 48°, and the average annual maximum temperature is 73°, with an average of 60.5°. The growing season in southwestern Oklahoma is relatively long. Records at the station reveal that the average frost-free period is from March 29 to November 3, a total of 219 days. The elevation of the station is slightly over 1100 feet.

Observations and discussion.—The observations reported here were made during the five-year period 1930–1934 on the Lawton field station and were confirmed by observations on farms in the vicinity.

Table 2.—Dates of emergence of corn and sorghums and approximate dates of maturity of principal crops attacked by chinch bugs at Lawton, Okla., for 1930–1934.

	Emergence Date		Maturity Date						
	Corn	Sorghums	Winter Wheat	Winter Barley	Spring Barley	Winter Oats	Spring Oats	Corn	Sorghums
1930	Apr. 30	May 27	June 17	*	June 23	*	June 16	July 26	Aug. 28
1931	Apr. 28	Apr. 25	June 13	June 3	June 6	June 3	June 15	Aug. 27	Sept. 30
1932	Apr. 20	Apr. 21	June 8	May 24	June 1	June 7	June 10	July 22	Aug. 20
1933	Apr. 9	Apr. 23	June 4	May 25	June 8	*	June 17	July 10	Aug. 20
1934	Apr. 10	Apr. 25	June 5	May 19	June 6	†	June 6	July 10	Aug. 20

* All varieties were winter killed.
† Not grown.

In 1930 chinch bugs migrated by flight from their winter quarters during the first half of April into the wheat and barley plots. Oviposition took place shortly after the migration. The eggs deposited on and near the wheat and barley plants gave rise to the first seasonal brood during the first and the second weeks in May. This brood remained in the small-grain plots until it had reached the adult stage, which was during the latter half of June. The adult bugs flew a short distance to the sorghum nursery, where the female adults started ovipositing about the young sorghum plants. Approximately 10 days later, or about July 3, the young of the second generation appeared. The bugs of this generation reached the adult stage during the first half of August. They remained in the sorghums, where the females started ovipositing for the third generation of the season. Young nymphs of the third generation appeared in large numbers about August 15 and fed on the maturing sorghum plants until they were harvested. The season was favorable for the development of second growth on the sorghum stubble, which furnished an abundant supply of food for the nymphs. The second growth of sorghums is sucker stalks that come up from the old stubble after the main crop has been harvested, which seldom, if ever, occurs in corn. Owing to the long growing season in this section, there is more or less second growth on sorghums every year. The third brood reached the adult stage shortly after the middle of September. Within a relatively short period these adults flew

to winter quarters, where they fed for a short time previous to hibernation. The life history of the three generations as observed during 1930, 1932, 1933 and 1934 is shown in fig. 1.

In 1931 the generations were not so distinct. Any instar of the bugs could be found throughout the growing season. Flight from winter quarters covered a longer period than it did in 1930. This condition appears to explain the fact that various stages of the bugs could be found throughout the season. The peak of the migration from winter quarters in 1931 occurred about the same time that it did in 1930, and the bugs remained in the sorghums over a similar feeding period before returning to hibernation quarters. In spite of the overlapping of the different generations, there is probably little reason to doubt the presence of a third generation, although the appearance of new broods was not clear cut as in the case of the other years. The data obtained in 1931 do not show definitely the presence of a third generation, but they do not preclude the occurrences of this additional generation.

In 1932 the number of generations and the dates of their occurrences were almost identical with those observed in 1930. About the middle of April the overwintering adults flew from winter quarters to the small-grain plots, where the young nymphs of the first generation appeared soon after the first of May. The small-grain crops offered ample food for the maturity of this brood, which occurred about the time the small grains were ripe. This condition made it unnecessary for the bugs to migrate on foot to the sorghums, and the hot soil between the crops encouraged migration by flight. After the bugs flew to the sorghums, oviposition took place, which ultimately gave rise to the second generation during the first few days of July. This brood fed on the growing sorghum crop until early August before reaching the adult stage. It remained in the sorghums, where oviposition gave rise to the nymphs of the third generation about August 15. By September 1 very few adult bugs of the second generation could be found, but second and third-instar bugs of the third generation were very abundant. The sorghum crop was harvested late in August, and second growth started within a few days. This supplied ample food for the bugs until they reached the adult stage. The bugs were observed feeding in large numbers on the old sorghum stubble until the second growth appeared. The third brood reached the adult stage shortly after the middle of September. They gradually flew to winter quarters, where they fed on new growth stimulated by fall rains and went into hibernation.

In 1933 a third brood of chinch bugs was observed under both field and cage conditions. Overwintering adults were placed in a cage on growing winter wheat at a time when the bugs were emerging from winter quarters. On May 5 young nymphs of the first generation of the season were observed in the field on wheat and barley. Conditions in the cage were cold and damp, and young nymphs did not appear in the cage until May 12. This first brood reached the adult stage in the small-grain crop about the middle of June.

About the middle of June, or shortly thereafter, the first-brood adults under field conditions migrated by flight to the sorghum nursery, and the

adults in the wheat cage were placed on Sudan grass in a cage. The first nymphs of the second generation were observed on June 25 in both the field and in the cage. After reaching the adult stage the second brood bugs in the field were forced to search for new food. The sorghums in the nursery had been either killed or hastened to maturity by the drought and the hot winds. These adults flew to a nearby block of Sudan grass. Eggs were deposited in the block of Sudan grass, and on August 15 young nymphs of the third generation appeared. The second brood adults in the cage remained on the Sudan grass. Several young third-brood nymphs were found on August 25 in the cage.

The third-brood bugs did not develop as rapidly as the two previous broods. This may be explained as due to lower temperatures common to the fall season. On September 25 many third-brood adults were found in both field and cage. Immature forms were in the last two instars. On October 15 practically all bugs under both field and cage conditions were in the adult stage. By November 1 all bugs observed were third-brood adults. The majority of the adults in the field on this date were concentrating in and around protected locations. Third-brood adults in the cage were seeking hibernation at the base of the Sudan grass plants.

In 1934 only field observations were made. On April 1 several overwintering adults were migrating by flight to the small-grain plots. Young nymphs of the first generation of the season were observed May 12 in the small-grain crops. This brood reached the winged stage in the wheat and barley, and the adults migrated by flight to the sorghum nursery. This migration occurred about the middle of June. On June 29 a few young nymphs of the second generation were observed on the sorghum plants, and by early July second-brood nymphs were very abundant. This generation reached the adult stage in the sorghum nursery, but the food supply was becoming exhausted because of the severe drought conditions, and the adults were forced to seek another source of food. Many of the adults migrated by flight to a block of Atlas sorgo which had withstood much of the dry weather. Other adults flew to nearby clumps of Johnson grass. Young nymphs of the third generation were observed about August 15 on the Atlas sorgo and Johnson grass plants. On September 25 very few second-brood adults could be found, and most of the third-brood bugs were in the last two instars. By October 20 practically all the bugs that could be found were adults of the third generation. On this date many of the third-brood adults were observed migrating by flight to winter quarters.

Effect of habit on control.—Reports elsewhere mention the mass migration of chinch bugs by foot as the usual method. This has not happened during the five years of observations in southwestern Oklahoma, where all migrations have been by flight. This is best explained by the fact that small grains mature about the time the first brood of bugs reaches the adult stage. Previous reports have been based on conditions farther north, where the bugs do not reach the adult stage until after the small-grain crops mature. Under such conditions it is necessary for the bugs to search for a new host before reaching the winged or adult stage.

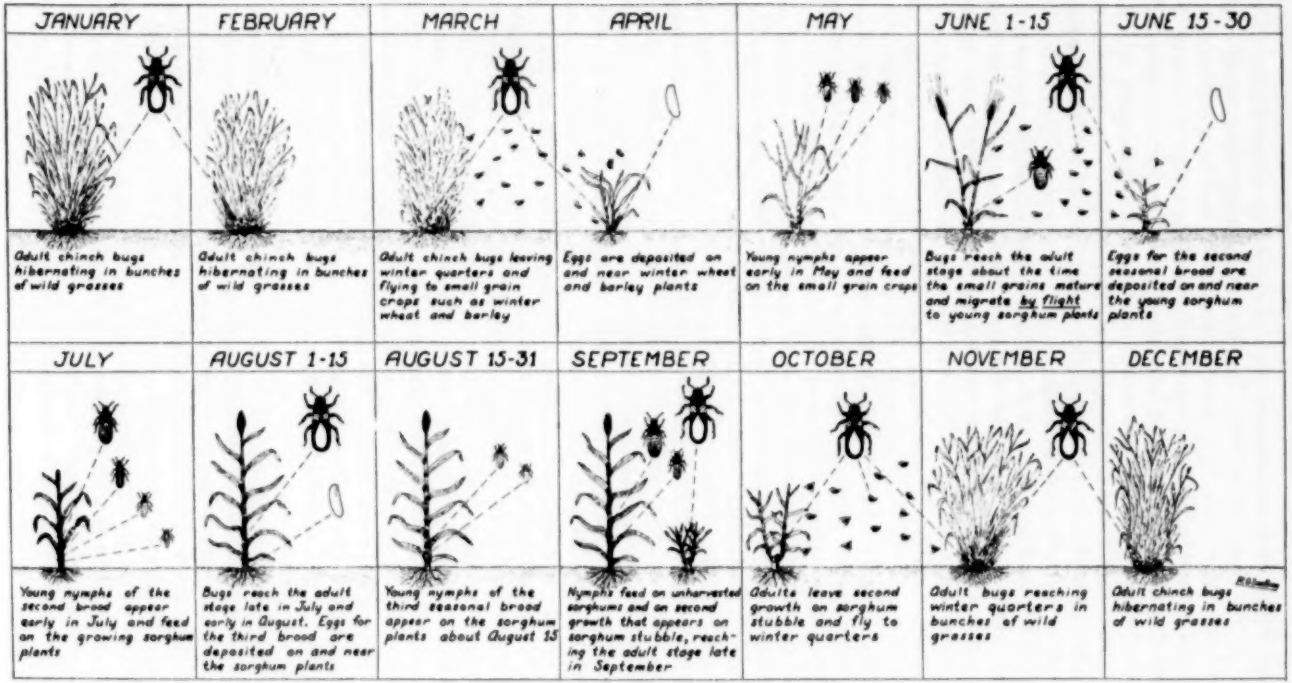
JANUARY
Adult chinch bugs hibernating in bunches of wild grasses
FEBRUARY
Adult chinch bugs hibernating in bunches of wild grasses
MARCH
Adult chinch bugs leaving winter quarters and flying to small grain crops such as winter wheat and barley
APRIL
Eggs are deposited on and near winter wheat and barley plants
MAY
Young nymphs appear early in May and feed on the small grain crops
JUNE 1-15
Bugs reach the adult stage about the time the small grains mature and migrate by flight to young sorghum plants
JUNE 15-30
Eggs for the second seasonal brood are deposited on and near the young sorghum plants
JULY
Young nymphs of the second brood appear early in July and feed on the growing sorghum plants
AUGUST 1-15
Bugs reach the adult stage late in July and early in August. Eggs for the third brood are deposited on and near the sorghum plants
AUGUST 15-31
Young nymphs of the third seasonal brood appear on the sorghum plants about August 15
SEPTEMBER
Nymphs feed on unharvested sorghums and on second growth that appears on sorghum stubble, reaching the adult stage late in September
OCTOBER
Adults leave second growth on sorghum stubble and fly to winter quarters
NOVEMBER
Adult bugs reaching winter quarters in bunches of wild grasses
DECEMBER
Adult chinch bugs hibernating in bunches of wild grasses

Fig 1.—Life history of three generations of chinch bugs during a year as observed at Lawton, Okla.

In sections where the migrations of all the generations of the chinch bug are accomplished by flight, the use of the creosote or tar barrier is futile as a means of control. Under conditions where three generations of bugs are common, control is still more difficult. The occurrence of a third generation of chinch bugs not only provides a greater number of bugs for hibernation, but in many cases this brood does considerable damage to sorghums that are late in reaching maturity. Observations have been made where the third-brood bugs have done considerable damage to a fall-sown wheat and barley after the late-maturing sorghums have been harvested.

The use of varieties of crops resistant to the ravages of the chinch bug offers, at the present time, the most promise as a means of avoiding damage. This method of reducing injury is especially important in sections where the chinch bug has three generations each year, and where all migrations are by flight. Atlas sorgo, a cross between Blackhull Kafir and Sourless "cane," is highly resistant to the chinch bug and is well adapted to a wide range of growing conditions. This dual-purpose variety of sorghum has white, palatable grain, is leafy, and has sweet, juicy stalks which are resistant to lodging. Atlas is more resistant to chinch bugs and produces higher yields than Standard Sumac, a variety which is widely grown for forage purposes. Atlas is rapidly increasing in acreage on farms and in popularity among farmers in the chinch bug-infested area of the sorghum belt.

The production of resistant varieties of corn and sorghum is being extensively studied at the United States Dry Land Field Station, Lawton, Okla., through informal cooperation between the divisions of Dry Land Agriculture and of Cereal Crops and Diseases, U. S. Department of Agriculture, and the departments of entomology and agronomy, Kansas Agricultural Experiment Station.—7-9-36.

Literature Cited

(1) **Dean, Geo. A.** 1909. Insects injurious to farm crops. Agricultural Education. Kan. State Ag. Coll. Farmers' Institute Series **1**(4):19–23. Illus.

(2) **Flint, W. P.** and W. H. Larrimer. 1926. The chinch bug and how to fight it. U.S.D.A. Farmers' Bul. **1498:** 1–16. Illus.

(3) **Headlee, Thomas J.** and James Walker McColloch. 1913. The chinch bug. Kans. Ag. Exp. Sta. Bul. **191:**287–353. Illus.

(4) **Horton, J. P.** and A. F. Satterthwait. 1922. The chinch bug and its control. U.S.D.A. Farmers' Bul. **1223:** 1–35. Illus.

(5) **Kelly, E. G.** 1929. Controlling crop insects. Kans. State Ag. Coll. Ext. Bul. **62:** 14–18. Illus.

(6) **Luginbill, Phillip.** 1922. Bionomics of the chinch bug. U.S.D.A. Bul. **1016:** 1–14. Illus.

(7) **McColloch, James W.** and H. Yuasa. 1914. A parasite of the chinch bug egg. Jour. Econ. Ent. **7**(2):219–27.

(8) **Shelford, V. E.** 1932. An experimental and observational study of the chinch bug in relation to climate and weather. Ill. Nat. Hist. Survey Bul. **19**(6):487–547. 37 figs., bibliog.

(9) **Webster, F. M.** 1915. The chinch bug. U.S.D.A. Farmers' Bul. **657:**1–28. Illus.

(10) **Wilson, R. N.** 1929. The chinch bug in relation to St. Augustine grass. U.S.D.A. Cir. **51:**1–6. Illus.

Scientific Notes

Toxicity of Certain Azo Compounds to Mosquito Larvae.—The discovery, in August 1934, that azobenzene was toxic to mosquito larvae led to an investigation of various substituted azo compounds. The method of testing them for toxicity was, briefly, as follows: the compound was dissolved in acetone, and calculated portions of the solution were added to beakers containing 100 cc. of water and 50 mosquito larvae entering the fourth stage. Those concentrations of the various compounds that produced a mortality of 50 per cent or higher in 16 hours were considered effective. Constant temperature was maintained during the test by means of a water bath, and all tests were run in duplicate. Where toxicity was found in very dilute solutions; more than two tests were made, so that a good average could be obtained, whereas when a compound was found to be ineffective at a concentration of 100 parts per million no attempt was made to determine whether it would be effective at a higher concentration.

A list of the compounds that were effective at the given concentrations follows.

Concentration parts per million	Compound
1.42	4-(p-bromophenylazo)-o-cresol
	4-(p-bromophenylazo)-resorcinol
1.66	p-bromophenylazophenol
	4-(p-bromophenylazo)-m-cresol
	4-(2, 5-dichlorophenylazo)-o-cresol
2.5	4-(2, 5-dichlorophenylazo)-m-cresol
	4-(2, 5-dichlorophenylazo)-resorcinol
	4-(p-iodophenylazo)-o-cresol
3.3	1-phenylazo-2-naphthylamine
	4-(p-nitrophenylazo)-resorcinol
5	azobenzene
	4-(p-bromophenylazo)-5, 6, 7, 8-tetrahydro-1-naphthol
	1-(p-bromophenylazo) 2-naphthylamine
	p-(2, 5-dichlorophenylazo)-o-cyclohexylphenol
	p-(2, 5-dichlorophenylazo)-phenol
10	phenylazo-o-cresol
	phenylazo-m-cresol
20	p-phenylazoaniline
	p-phenylazophenol
40	1-(o-tolylazo)-2-naphthylamine
100	4-(2, 5-dichlorophenylazo)-3-ethoxyphenol
	4-(2, 5-dichlorophenylazo)-2, 5-xylenol
	p-phenylazodimethylaniline
	p-phenylazodiphenylamine
	p-iodoazobenzene

Twenty-three other azo compounds were tested, but proved ineffective. When more detailed results are obtained it is proposed to subject them to a more critical analysis from the standpoint of possible correlation between chemical constitution and insecticidal action.

D. E. Fink and D. L. Vivian, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.* 7-10-36

Toxicity of Certain Organic Compounds to Culicine Mosquito Larvae.—Since the report of 1934,* about 400 compounds have been obtained or prepared by members of the Division of Insecticide Investigations and tested by the Division of Control Investigations for their toxicity to mosquito larvae, which serve as convenient test insects, in a search for organic insecticides to replace inorganic insecticides that may be hazardous to human health. A full report on the progress of this work is in preparation.

Briefly stated, the tests were carried out by adding calculated portions of acetone solu-

* Campbell, F. L., W. N. Sullivan, L. E. Smith and H. L. Haller. Jour. Econ. Ent. 27(6):1176-85. Dec.

tions of each compound to beakers containing 100 cc. of distilled water, transferring to these beakers 50 larvae beginning the fourth stage, maintaining the whole at 26° C for 16 hours in a constant-temperature water bath, and counting the number dead at the end of this period. The concentrations used ranged from 1 to 100 parts per million parts of water.

The more toxic compounds and the minimum concentrations at which a mortality of 50 per cent or more resulted within the 16-hour period are listed below.

CONCENTRATION parts per million	COMPOUND
2.	6-methylphenothiazine
	phenothioxin
2.5	4-chloro-2-nitrodiphenylamine
3.3	dibenzothiophene (diphenylene sulfide)†
5.	thioxanthydrol
	6-ethylphenothiazine
	dibenzofuran (diphenylene oxide)†
	alpha fural p-methylacetophenone
	2-chlorodibenzofuran (2-chlorodiphenylene oxide)†
	2-aminodibenzofuran (2-aminodiphenylene oxide)†
	alpha bromo p-phenylacetophenone
	2-methylanthraquinone
	p-chlorobiphenyl
	2-cyclohexyl-4, 6-dinitrophenol
	2, 3, 4, 6-tetrachlorophenol
	phenanthrene
	1-nitro-2-naphthylamine
	xanthene
	4-chloro-2-nitrophenyl ester of thiocyanic acid
	triphenyl ester of trithioarsenious acid
	n-phenyl-1-naphthylamine
	1, 2, 3, 4-tetrahydrocarbazole
	p-bromonitrobenzene
	p-dinitrobenzene†

† A detailed report covering this type of organic compound is in preparation.

D. E. FINK and L. E. SMITH, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.* 7-10-36

Beet Leafhopper on Texas Spinach.—A severe outbreak of beet leafhoppers, *Eutettix tenellus* (Baker), transmitting curly top in spinach, occurred for the first time in the Winter Garden area of Texas in the late winter and spring of 1935-36. This is the largest spinach-producing area in the world, and anything which is destructive to this crop is of considerable importance. The yield was reduced as much as 75 per cent or more in some fields. The disease was quite uniformly distributed in Dimmit, Maverick, Webb, and Zavala counties. Growers reported that the disease was also present in many of the other counties of south Texas where spinach was grown this year. The outbreak began early in January and lasted until the spinach growing season was over in April.

Diseased spinach was sent to B. F. Dana, plant pathologist, U. S. Bureau of Plant Industry, and he diagnosed the disease as curly top. Specimens were also sent to Dr. Henry H. P. Severin, associate entomologist, University of California. He reported as follows: "Previously noninfective beet leafhoppers after feeding on diseased spinach were transferred to sugar beets which developed typical symptoms of curly top, demonstrating that spinach was naturally infected with curly top in Texas." Dr. Severin also stated that the diseased table beets sent him from the Texas Winter Garden "showed the cleared veinlets and protuberances on the lower surface of the leaves, both reliable symptoms of curly top." Leafhoppers collected by M. J. Janes, entomologist of the Texas Experiment Station, and the writer, were identified as *Eutettix tenellus* (Baker) by Dr. D. M. DeLong, professor of entomology, The Ohio State University; Dr. R. K. Fletcher, entomologist, Texas Experiment Station; and Dr. Severin.

Early spring tomatoes were damaged by tomato curly top. About 60 per cent of the plants were killed in one field. Table beets were also affected.

Beet leafhoppers were present in large numbers until the latter part of April. Although a wide variety of plants was swept with a net in the vicinity of Texas substation 19, Winter Haven, not one beet leafhopper was found after May 15, 1936. An explanation of the sudden disappearance cannot be given at present. The rainfall was 3.78 inches from October 1, 1935, to April 22, 1936. Of this amount only .44 inch fell after January 1. Plants in irrigated fields were suffering from lack of moisture in April. The rainfall from April 22 to May 31, 1936, was 5.20 inches with 1.91 inches in one day. It is not known whether the beet leafhoppers migrated to more succulent food during the drought or were killed by heavy rains.

S. E. JONES, *Texas Agricultural Experiment Station, Winter Haven.* 7-11-36

Effect of Low Temperature in Shortening Hibernation Period of Insects in the Egg Stage.—Buds of woody plants of the temperate zone become dormant in early fall and do not resume growth until they have been subjected to a period of low temperature. The required time at low temperature varies greatly with different species. Certain seeds, bulbs, tubers and other plant parts are also dormant and some require low temperature preceding the resumption of growth. This suggests the possibility that insects of the colder temperate zone region which hibernate in the egg stage may also respond to a low-temperature cycle.

The eggs of the species of insects described in this paper when collected were immediately placed in closed glass containers. They were then subjected to various constant temperatures and were transferred at definite intervals to room temperature.

Egg masses of the eastern tent caterpillar, *Malacosoma americana* (Fabr.), collected in the fall of 1934, hatched at room temperature when given a pretreatment of eight to 12 weeks at 1, 5 and 10° C. The time required for hatching decreased as the period at low temperature increased. No hatching of larvae was obtained from those kept constantly at room temperature. The low temperature treatment not only affects the number of hatches obtained but also affects the rate of emergence when transferred to room temperature. The out-of-doors conditions are also favorable in bringing about the hatching of larvae from the eggs when brought into room temperature after the winter has advanced sufficiently to correspond to our experimental low temperatures. The eggs from out of doors brought to room temperature in late March of this year hatched within three to eight days and gave a very high average per egg mass. This indicates that the conditions during the winter were very conducive to maximum hatching within a minimum time.

This phenomenon of low-temperature cycle is of importance in timing application of ovicides under laboratory conditions. The above experiments show that eggs of the eastern tent caterpillar do not hatch unless given a pretreatment at low temperature. If the eggs are not subjected to low temperature, the failure to hatch may not be due to toxicity of the ovicide, but due to the physiological condition of the eggs.

The eggs of the fall cankerworm, *Alsophila pometaria* Harris, also respond to low-temperature exposures; while a few hatch when kept constantly at room temperature (about 22° C), a much higher percentage hatched at room temperature when preceded by periods of from three to 18 weeks at 1, 5, 10 and 15° C.

No low-temperature treatment is required for the hatching of nymphs of the Chinese praying mantis, *Paratenodera sinensis* (Saussure). However egg masses subjected for three to 12 weeks at 5° C were not injured. As this species ranges from subtropical regions northward, the eggs would not be likely to require pretreatment of low temperature which is consistent with our experimental results.

The results reported in this paper are believed to be of general biological interest in that eggs of certain species of insects respond similarly to low temperature as do certain plant parts and seeds. A more detailed report will appear in volume 8, Contributions from Boyce Thompson Institute.

FLORENCE FLEMION and ALBERT HARTZELL, *Boyce Thompson Institute, Yonkers.* 6-26-36

Further Observations on the Oblong Leaf Weevil in Western New York.—In 1928 Dr. E. P. Felt (N.Y. State Museum Bul. **274**:158-9) reported that the oblong leaf weevil, *Phyllobius oblongus* L., was found in the United States for probably the first time when adults of this species were taken from three large American elm trees in a Rochester, N. Y. park during June and early July 1923. Since this report the insect was apparently not noticed again in the United States until May 1934, when adults were found in a neglected pear orchard at East Penfield, 12 miles east of Rochester, by R. C. Coombs, W. D. Mills

and C. R. Crosby. Specimens taken were identified as *Phyllobius oblongus* by Henry Dietrich of Cornell University. During the latter part of June 1934 the writer made as many observations as time permitted of the distribution and activities of this insect. A brief survey, during which mainly pear trees were examined, revealed that the insect was present in numerous localities in Monroe and western Wayne counties within a 20-mile radius of Rochester, although the exact limits of distribution were not determined. Observations on May 29, 1936, indicated that the species was again abundant in the same orchard where it was discovered in 1934.

References in the literature indicate that *P. oblongus* is most common in northern Europe and that the favorite host plants of the adults include the common tree and bush fruits as well as the more tender portions of certain forest trees. The adults are primarily leaf feeders and also attack developing buds. Relatively little appears to be known about the larvae although they are known to feed on strawberry roots in the British Isles. From European references it appears that the adults emerge from the ground during the spring to mate and feed upon foliage. Oviposition apparently takes place in the soil and the larval and pupal stages are spent under ground.

In 1934 the writer observed adults feeding on the foliage of pear, apple, plum, chokecherry, strawberry and raspberry at East Penfield, N. Y., although pear foliage seemed to be most attacked. Brief examination during the latter part of May 1936 revealed adults feeding on pear, apple and plum. More tender parts of the foliage were especially subject to attack and, on pear, large numbers of adults were occasionally found on the leaves of water sprouts. Most of the observed foliage injury was found in neglected orchards and it appears probable that the amount of serious feeding injury is reduced in sprayed orchards.

LAURENCE A. CARRUTH, *New York State Agricultural Experiment Station, Geneva.* 6-18-36

***Bruchus brachialis* Fahraeus in Georgia.**—On a recent auto trip to Atlanta, Ga., and return the writer had the opportunity of doing a small amount of roadside collecting in North Carolina, South Carolina and Georgia. *Vicia villosa*, the bruchid host, was in bloom in these three states. As a result of sweeping this plant adults of *Bruchus brachialis* were taken in twelve counties not yet reported as being infested, *U.S.D.A.* Insect Pest Survey Bul. **15**(5):231 and **15**(10):448.

The localities and collecting dates are as follows:

NORTH CAROLINA.—Henderson, Vance county, May 2; Oxford, Granville county, May 2; Durham, Durham county, May 2; Efland, Orange county, May 2; Madison, Rockingham county, May 9; and King's Mountain, Cleveland county, May 3.

SOUTH CAROLINA.—Blacksburg and Gaffney, Cherokee county, May 3; Lyman, Spartanburg county, May 8; Greer, Greenville county, May 3; Central, Pickens county, May 8; and Seneca, Oconee county, May 8.

GEORGIA.—Clarkston, DeKalb county, May 7.

The single example of the vetch bruchid taken at Clarkston is the first known from Georgia. Although negative results were obtained by sweeping vetch in several other localities north and east of Atlanta, it is to be expected that the bruchid will soon be found in numbers in that part of the state.

L. J. BOTTIMER, *U.S. Department of Agriculture*, Haddon Heights, N. J. 7-3-36

***Spathius canadensis* Ashm., a Parasite of *Hylurgopinus rufipes* (Eich.).**—In the course of their investigations on the life history and habits of the native elm-bark beetle, *Hylurgopinus rufipes* (Eich.), the authors have encountered the braconid parasite *Spathius canadensis* Ashm. (det. by C. F. W. Muesebeck), and have specimens reared from cocoons in material from Amherst, Mass., and Barkhamsted, Cheshire, Orange, Washington and South Windham, Conn. Adults also have been collected on elms in Stamford, Haddam and Hartford, Conn. Further studies are to be carried on to determine something of its habits and the degree of parasitism.

It is interesting to note that this parasite has also been reared from elm logs infested with *Magdalis barbita* (Say) and *M. armicollis* (Say). From this and records in literature it would appear to be markedly polyphagous, the other hosts being as follows: *Phloeosinus dentatus* (Say), *P. graniger* Chap., *Ips grandicollis* (Eich.), *Dryocoetes americanus* Hopk., *Tomicus* sp., *Magdalis olyra* Hbst., *Scolytus rugulosus* Ratz., and *Pissodes strobi* Peck.

B. J. KASTON, *Connecticut Agricultural Experiment Station, New Haven*, and W. B. BECKER, *Dutch Elm Disease Laboratory, Department of Entomology, Massachusetts Experiment Station, Amherst.* 6-4-36

JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

Vol. 29 August 1936 No. 4

INDUSTRY'S CHALLENGE TO YOUNG ENTOMOLOGISTS

DEVELOPMENT of insect control measures by chemical means of insecticides is an interesting chapter in the history of entomology. At an early date individuals began working independently in search of chemicals or combinations of materials that would kill certain insect pests, the basis of their endeavors being the principle that anything obnoxious to man should prove to be a good insecticide.

During this period a few materials containing valuable constituents were accidentally discovered. Then with the organization of the U. S. Bureau of Entomology and the state experiment stations a more scientific approach was afforded by the assistance of trained chemists. We proceeded on this basis for several years until the formation of a new agency, the Crop Protection Institute, an outgrowth of the American Association of Economic Entomologists, whose purpose was to align industry with scientific researc hand stimulate and formulate a new angle of approach. Industry was now faced with a scientific approach to the problem of the development of insecticides and the challenge which was thrown down has been accepted by them in a real way.

It is probably safe to say that the major developments in the future in this field of research will be brought about largely through industry. There are probably several reasons why this change has taken place, chief among which is certainly the fact that industry has been called upon to manufacture and distribute these chemical materials and is interested in placing upon the market the material that will best accomplish the control and for which there is greatest demand. Also, development of the U. S. government and experiment station projects and the administrative and routine duties which have been necessary, together with the recent depression and reallocation of funds, have largely prevented a natural development in this field of research by these institutions.

This new situation offers excellent opportunities for young men who are properly trained and qualified to undertake these studies, an opportunity not offered to those of us who began working in entomology a score of years earlier. It is an opportunity to approach a problem from the various angles of insect toxicity, chemistry, physics and human and plant physiology; an opportunity to work with men who are specialists in these allied scientific fields and the stimulating influence and breadth of vision which come from such contacts. To take advantage of this opportunity, the applicant has only one demand or requirement placed upon

him. He must have broad basic training, ability and industry. Without further superficial formalities he is then ready for testing on the proving block of scientific research.

Present indications are that industry will go even further and stimulate and encourage basic work in biology and ecology as well as chemical control.

Many of our better trained and most promising young entomologists are finding the most interesting and finest opportunities for research in these positions which industry has offered.

DWIGHT M. DELONG

Review

General Entomology, by Robert A. Wardle. 1936. 8 vo., cloth, vii+311 pp., 96 illus. P. Blakiston's Son & Co., Philadelphia. $2.25.

This work by Professor Wardle of the University of Manitoba is "intended for students to whom the subject of entomology represents merely one or two courses of the many that comprise their training for the profession of zoology and agriculture, and who do not require the detailed knowledge of insect morphology and insect classification that is essential to the professional entomologist but do require a broad appreciation of the basic principles of the subject."

The book is composed of 12 chapters, the first five of which treat the subjects of anatomy, development, physiology and behavior. The remaining seven chapters discuss, in a brief systematic manner, the class nsecta under 10 superordinal divisions which include 40 fossil and present-day orders. As an example, besides the proturoid group, chapter 6 discusses the palaeopteroid insects, which includes the following orders: Palaeodictyoptera, Protorthoptera, Palaeoptera (Blattidae), Dictyoptera (Mantidae), and Isoptera. The first two of these are fossil orders. To the economic entomologist this book holds chief interest in the earlier chapters where many of the newer developments in anatomy, physiology and behavior are concisely brought together. In the later chapters, keys to superfamilies or important families are included and each group is discussed briefly, in many instances containing only a list of important species without recognition characters of the family as a whole. Control measures are entirely eliminated. An interesting innovation is the inclusion under various families of the names of authorities in the group but without citation to their principal works, which would have been of value to the class of students for which it is intended. The book has been revised and criticized by Dr. J. W. Folsom, from whose noted work some of the illustrations are taken to supplement a number of original well-done figures.

WM. P. HAYES. 7-13-36

Current Notes

PUBLISHERS OFFER LITERARY PRIZE IN SCIENCE

A cash award of $1000 is offered by the Williams & Wilkins Company for the best manuscript on a science subject, presented before July 1, 1937. The publishers put no limitations on the subject matter or manner of handling, and none on eligibility for the award. The MS. must be in English and of a sort calculated to appeal to the taste of the public at large. The desired length is given as 100,000 words.

While any MS. on a science subject will be considered, it is expected that the author will prove to be a man or woman engaged in a scientific pursuit and who is possessed of the requisite literary skill to interpret science for that portion of the public which reads books.

To assure authenticity, the publishers have enlisted the services of some 25 or 30 "advisers," these being men of science of reputation and competence. One or more of the advisers will pass upon each MS. from the viewpoint of soundness and accuracy. The award will lie in the joint discretion of four judges selected with a view to their especial qualification in choosing the sort of book that will appeal. These are:

Dr. Joseph Wheeler, librarian of the Pratt Library in Baltimore and chairman of the book-list committee of the American Association for the Advancement of Science; Harry Hansen, reviewer and critic for the New York World-Telegram and Harpers Magazine; Dr. Lyman Bryson, professor of education in Teachers College, Columbia University, and director of the "Readability Laboratory"; and David Dietz, science editor of the Scripps-Howard newspapers.

Details concerning the award may be had by addressing the publishers at Mt. Royal and Guilford avenues, Baltimore.

D. M. DeLong, professor of entomology, The Ohio State University, Columbus, has returned to Urbana, Illinois, for the third consecutive summer of field work on the Cicadellidae of Illinois. The project will result in a publication on this family by the Illinois Natural History Survey, under whose auspices the work is being conducted.

ROYAL AGRICULTURAL SOCIETY OF EGYPT OFFERS PRIZE FOR COTTON-LEAF WORM CURE

The Royal Agricultural Society of Egypt has decided to grant a prize of twenty thousand Egyptian pounds to the inventor of a preventive remedy for the affliction of the cotton leaves caused by the worm known as *Prodenia litura*. The remedy must be one that prevents appearance of the white blotches that result from presence of the eggs or larvae of this pest. The society, founded in 1898, issues the following rules of competition, as recently submitted to the Secretary of State by the Minister of Egypt in Washington.

The administrative council of the Royal Agricultural Society will grant the prize in accordance with the decision of the committee for the combat of the cotton worm, which is entrusted with the examination of all remedies submitted in this competition. The committee's decision and the approval of the council are final, and are not subject to opposition or appeal.

For admission to this competition for the above prize, the following documents must be submitted to the secretariat of the Royal Agricultural Society:

(a) A written detailed statement, signed by the applicant, containing a full description of the remedy, its composition and method of application, as well as all other explanations considered by the applicant to be useful and necessary. Two copies of this statement must be submitted in an envelope closed and sealed with wax by the applicant,

(b) If the remedy comprises the application of a certain definite substance, two samples of the same must be submitted to the secretariat of the Royal Agricultural Society, enclosed in a suitable container and also sealed with wax and signed by the applicant.

(c) A declaration identical with the one at the end of this notice, dated and signed by the applicant.

Members of the Committee for the Combat of the Cotton Worm are not permitted to participate in this competition.

Applicants in this competition must belong to a recognized scientific body, or be presented by a public or scientific institute of recognized Egyptian origin, if the applicants are Egyptians, or recognized abroad if the applicants are residents of other countries.

The Royal Agricultural Society reserves to itself the absolute right, after making the experiments which will be hereinafter mentioned, to determine whether the remedy deserves the prize offered or not, without giving reasons therefor.

Every remedy presented and found worthy of consideration by the society shall be the object of experimentations for a period of six years, the society having the right to extend the period another year. If the council decides after this period of experimentation that the remedy is efficacious, the prize will thereupon be paid the inventor.

The remedy must protect the cotton plant against attack by the cotton-leaf worm, without being injurious to persons, animals or agriculture. In addition the application of the remedy should not be costly so that it will not absorb a considerable part of the price of the product.

In case more than one remedy, submitted by two or more persons before the expiration of the time set for the submission of applications, proves efficacious, the society reserves the

absolute right to divide the prize between them according to the merit of each in the society's judgment.

No application for entrance in this competition is accepted after one year from announcement thereof.

DECLARATION

I, ————————————, the undersigned, having submitted on this day to the Royal Agricultural Society a preventive remedy against the cotton-leaf worm, for participation in the competition for the prize assigned by the said society, do hereby declare that I have seen the conditions in accordance with which this prize is granted and which appear as printed above, and do accept the same in their entirety and without reservation.

And I do specifically agree that the society has the absolute right to determine whether the remedy submitted by me is efficacious or not, without any right on my part to object to the decision. I also agree that in case the society determines that my remedy is not efficacious, I will have no right to the prize, in part or in whole, nor to any compensation whatsoever.

I accept the society's decision as final, and agree that it is the sole judge in the irrevocable decision, in accordance with the conditions of this competition.

(Applicant's signature)

Horticultural Inspection Notes

National Plant Board Report for 1935.—A synopsis of the Board's annual meeting, held at Miami, Fla., February 4 to 8, will be found in the JOURNAL **28**(2):503–4, April.

A report of the Quarantine Conference, called by the National Plant Board at Chicago, Ill., November 5 and 6, appears in the JOURNAL **28**(6):1083–4, December. In addition, the Board report presented at this time referred to the following resolutions adopted unanimously referring to uniform standards of inspection and certification of nursery stock.

WHEREAS, there exists a lack of uniformity with respect to the practises and procedures followed with regard to the conditions and requirements attached to the shipment of nursery stock interstate, and uniformity and standardization of procedure is most desirable in order to facilitate and at the same time safeguard, from the pest-risk standpoint, such plant transportation, and

WHEREAS, the plant quarantine officers of the various states assembled in conference at Chicago, Illinois, this sixth day of November 1935 recognize the necessity for action of a constructive character for the development of a program calculated to accomplish this objective, now therefore

BE IT RESOLVED, that it is the sense of this conference that the National Plant Board shall initiate the necessary steps to create a closer relationship, a coordination and correlation between the several states, and between the states and the federal plant quarantine organization, and

BE IT RESOLVED FURTHER, that the National Plant Board be requested to cooperate with the Bureau of Entomology and Plant Quarantine in formulating and submitting to the several states, a set of standards which shall serve as the basis for the inspection of nurseries and the issuance and use of inspection certificates to accompany interstate nursery stock shipments, with the expectation that ultimately those states adopting and following such standards will be authorized to issue federal certificates of nursery inspection to accompany interstate nursery stock shipments.

W. C. O'KANE, *Chairman*

Central Plant Board Report for 1935.—A synopsis of the Board's annual meeting held at Urbana, Ill., February 27, 1935, will be found in the JOURNAL **28**(2):503, April.

P. T. ULMAN, *Chairman*

FEDERAL QUARANTINE NO. 6, promulgated in March 1913 to regulate the interstate movement of date palms and date-palm offshoots from certain areas in California, Arizona and Texas on account of date-palm scale insects, was revoked effective July 1. "Eradication of this pest, which has been the subject of a vigorous eradication campaign conducted cooperatively by the affected States and the United States Department of Agriculture for a number of years," the press notice states, "has apparently now been effected, as intensive

inspection of the previously infested areas has revealed no infestation since 1934, the infestation at that time being extremely light."

COMPLAINTS OF MISSISSIPPI nurserymen as to paying fees in order to make shipments to other states, lead the Mississippi legislature recently to pass a law empowering the Plant Board to make reciprocal agreements with officials of other states, under which nursery stock from any other state may be sold in Mississippi under the same conditions as Mississippi stock is sold in such states. The board announces it will require fees and bonds in the same amount as those imposed on Mississippi nurserymen shipping to the state concerned.

THE MISSISSIPPI quarantine relating to alfalfa weevil was recently amended to apply to the entire states of Idaho, Nevada, Utah and Wyoming, one county in Arizona, 12 in California, 11 in Colorado, two in Nebraska and five in Oregon.

HAND INSPECTION of peach and nectarine trees for the peach-tree borer is no longer required under the Mississippi regulations relating to the phony peach disease as recently revised. Public notice was also recently given that 17 counties in the state constitute a special eradication area within which trees infected with the disease must be destroyed.

THE STATE OF IDAHO has made arrangements with federal departments to reestablish terminal inspection at 21 points in Idaho, under authority of the act of March 4, 1915. This order relates to parcel-post shipments of nursery stock, plants and plant products other than plants shipped under the certificate of the federal Bureau of Entomology and Plant Quarantine or the Idaho State Department of Agriculture.

A NUMBER OF WHITE PINE blister rust control areas have been established around nurseries in Ohio under provisions of the state regulations concerning the suppression of the rust, issued effective October 15, 1935. In Maryland, control areas were recently established in three counties, a public park, and a reservation, under regulations of December 1, 1935. The latter order also makes provision for the state horticultural department to accept as blister rust control areas, other white pine plantings or nurseries when feasible to carry out the control procedure.

THE COLORADO quarantine relating to the alfalfa weevil was revised on March 10 to bring under regulations two counties in Nebraska and one in Arizona, to release certain areas in Idaho and to provide for the conditional entry, part of the year, of hay from two counties in Wyoming. Montezuma county, Colo., is designated as infested in the Colorado quarantine relating to the weevil in that state.

NORTH CAROLINA, Indiana and Illinois have recently placed quarantines providing for the suppression or eradication of the Japanese beetle in localities in these states where infestations have recently been found. Certain spot infestations in Virginia and West Virginia not covered by federal quarantine are also brought under regulation by state action.

PAUL H. APPLEBY, Assistant Secretary of Agriculture, accompanied Lee A. Strong, Chief of the Bureau of Entomology and Plant Quarantine, on a tour of inspection of the WPA project in white pine blister rust control through the white pine growing areas of Minnesota, Wisconsin and Michigan, during the week of June 14. Henry N. Putnam, in charge of the control work in the lake states and stationed at Milwaukee, Wis., accompanied them. The state leaders and the state entomologists directed the tour in their respective states.

OREGON ORDER NO. 34 pertaining to the vegetable weevil in California was revised recently to add celery to the list of host plants of this pest, according to Frank McKennon, Chief of the Oregon Division of Plant Industry. Other host plants listed as liable to be carriers included are all parts of the plant except the seed of carrots, turnips, radishes, spinach, mustard, rape, root celery or celeriac.

REGULATION NO. 9 recently issued by Walter J. Marion, Chief of the Division of Plant Industry of the Ohio Department of Agriculture, outlines rules and regulations for the suppression and control of white pine blister rust in that state. Blister rust control areas are established and the replanting of currants and gooseberries in these areas is prohibited. The European black currant is likewise declared a public nuisance and its possession declared illegal.